IRC:135-2023

GUIDELINES FOR DEVELOPMENT OF BUS PORTS IN INDIA

INDIAN ROADS CONGRESS

2023

GUIDELINES FOR DEVELOPMENT OF BUS PORTS IN INDIA

Published by:

INDIAN ROADS CONGRESS

Kama Koti Marg,
Sector-6, R.K. Puram,
New Delhi-110 022

JULY, 2023

Price: ₹600/-
(Plus Packing & Postage)

IRC:135-2023
Guidelines for Development of Bus Ports in India

Author's Name
Indian Roads Congress

Published by
Indian Roads Congress

Publisher's Address
Kama Koti Marg, Sector-6, R.K. Puram, New Delhi-110 022

Printer's Details
Aravali Printers & Publishers Pvt. Ltd., New Delhi-110 020

Edition Details
First Published, July, 2023

(All Rights Reserved. No part of this publication shall be reproduced, translated or transmitted in any form or by any means without the permission of the Indian Roads Congress)

600 Copies

CONTENTS

S.No.	Description	Page No.
Personnel of the Highways Specifications and Standards Committee		i-ii
1.	**Introduction**	1
1.1	Background	2
1.2	Purpose of Bus Ports	3
1.3	Objectives of Bus Port Planning	3
1.4	The Objective of the Bus Port Guidelines	5
2.	**Planning Principles**	5
2.1	Introduction to Planning Principles	5
2.2	Bus Port Function	7
3.	**Assessment of Regional Travel Demand**	8
3.1	Intercity Per Capita (External) Bus Trip Rate (PCEBTR)	8
3.2	Planning Horizon	9
3.3	City Spatial Structure	9
3.4	Assessment of Gross Bus Port Demand	10
3.5	Assessment of Number of Bus Ports	10
3.6	Selection of Bus Port Location	11
3.7	Identification of Bus Port Location	12
3.8	Capacity Assessment	14
4.	**Planning and Design of Bus Port Infrastructure**	22
4.1	Bus Bay	22
4.2	Dwell Time	22
4.3	Passenger Loading Capacity at Bay	23
4.4	In case Primary Survey Data is unavailable	25
4.5	Estimation of Boarding Bays	25
4.6	Estimation of Alighting Bays	26
4.7	Estimation of Idle Parking Bays	26
4.8	In case Primary Survey Data is available	26
4.9	Estimation of Idle Parking Bays	27
4.10	Entry/Exit Points and Circulations (Vehicles only)	32
4.11	Parking and Pickup Drop off Facilities	33
4.12	Provisions for Pickup/Drop off and Parking	33
4.13	Bus Movement, Geometrics and Design	34
4.14	Decelerating Lane	36

S.No.	Description	Page No.
4.15	Lane Width	36
4.16	Gradient	37
5.	**Planning and Design of Passenger Amenities**	45
5.1	Multimodal Integration	45
5.2	Universal Access	56
5.3	Travel Information and Signage	60
5.4	Safety and Security	62
6.	**Design Typologies**	67
6.1	Basic Design Grid and Anthropometric Planning Module	67
6.2	Space Standard and Functional Modules	69
6.3	Level of Service	71
6.4	IPT and Private Parking	73
6.5	Typologies	75
6.6	Traffic Circulation Planning at Bus Ports	78
7.	**Operations and Maintenance Guidelines**	79
7.1	Introduction	79
7.2	Objectives	79
7.3	Broad Scope of Work	80
7.4	Allowable Activities in a Bus Port	82
7.5	Maintenance Standards	83
8.	**Other Related Elements**	88
8.1	Multi-Level Car Parking (MLCP)	88
8.2	Traffic Impact Assessment	91
8.3	TIA Recommendations - Improvement Proposals	99
8.4	Passenger Amenities Assessment	100
9.	**Case Studies**	119
Annexure		123

LIST OF FIGURES

S.No.	Description	Page No.
Fig. 1.1	Stakeholders Requirements	3
Fig. 1.2	Bus Port Planning considerations from the Passenger Perspective	4
Fig. 1.3	Bus Port Planning considerations from a Feeder Transport Service Perspective	4
Fig. 1.4	Bus Port Planning considerations from Operator/Driver Perspective	5
Fig. 3.1	Flow Chart for Identification of Bus Port Location	12
Fig. 3.2	Site Selection Parameters - Drivers	12
Fig. 3.3	Bus Port Infrastructure	15
Fig. 4.1	Parallel Loading Berths	28
Fig. 4.2	Shallow Sawtooth Loading Berth Design	29
Fig. 4.3	Proposed Access Modes at the Bus Ports for Planning	34
Fig. 4.4	Recommended Parking Spaces for various Modes at the Bus Ports	34
Fig. 4.5	Decelerating Lanes for Buses	36
Fig. 4.6	Standard Dimensions for Vertical Geometry	37
Fig. 4.7	Standard Dimensions for Shallow Saw-tooth Bays	39
Fig. 4.8	Section through Bus Platforms	40
Fig. 4.9	Standard Dimensions for Angular (45 degree) Bays	40
Fig. 4.10	Standard Dimensions for Angular (60 degree) Bays	41
Fig. 4.11	Standard Dimensions for Angular (90 degree) Bays	41
Fig. 4.12	Standard Dimensions for Bus Parking	42
Fig. 4.13	Standard Dimensions for Multi-Axle Bus Parking	42
Fig. 4.14	Standard Dimensions for Multi-Axle Bus Parking with Parallel Bays	43
Fig. 4.15	Standard Dimensions for Bus Parking with Angular Bays	43
Fig. 4.16	Standard Dimensions for Low-Floor Bus Parking	44
Fig. 4.17	Standard Dimensions for Low-Floor Bus Parking with Parallel Bays	44
Fig. 5.1	Degrees of Connections for Bus Port Sites	45
Fig. 5.2	Degrees of Connections for Bus Port Sites	46
Fig. 5.3	Schematic Zoning for a Bus Port Building	47
Fig. 5.4	Access Conditions depending On-Site Access	47
Fig. 5.5	Basic Horizontal Segregation of Circulation	48
Fig. 5.6	Segregation of Access and Egress through Grade Separation	48
Fig. 5.7	Segregation of Park & Ride from other circulation	48

S.No.	Description	Page No.
Fig. 5.8	Vertical Integration - Kashmere Gate RRTS to ISBT and Metro	50
Fig. 5.9	Horizontal Integration - Anand Vihar RRTS to ISBT, Metro & Railway Station	51
Fig. 5.10	Integration of Modes Across Barriers at Welcome Metro Interchange Station	51
Fig. 5.11	Sight Angles for Buses	58
Fig. 5.12	Tactile Pavers	59
Fig. 5.13	Sample Signage	61
Fig. 5.14	Components of a CCTV System	63
Fig. 6.1	Anthropometric Modules: Passenger Standing, Sitting, Ticketing and Staff Workstation	67
Fig. 6.2	Basic Planning Module with Variations in Office Module	68
Fig. 6.3	Additive Modules for Vertical Expansion	68
Fig. 6.4	Combined Module Serving 10 Bus Bays	69
Fig. 6.5	Vehicle Turning, Drop-offs and Parking	75
Fig. 6.6	Parametric System for Development of Layout Options	75
Fig. 6.7	Site Dimensions for Sample 20 Bay Bus Port	76
Fig. 6.8	Zoning for Sample 20 Bus Bay Port	77
Fig. 6.9	Movement for Sample 20 Bus Bay Port	77
Fig. 6.10	Layout for Sample 20 Bus Bay Port	78
Fig. 6.11	Traffic Circulation Planning at Entry and Exit of the Bus Ports	79
Fig. 8.1	Methodology for Traffic Impact Assessment for Bus Port	94
Fig. 8.2	Questions can be put in the Survey Formats	104
Fig. 8.3	Lost and Found Kiosks	105
Fig. 9.1	Bird View of Pandit Nehru Bus Station Vijayawada, Andhra Pradesh State	122
Fig. 9.2	Pedestrian Safety Measures at Pandit Nehru Bus Station Vijayawada, Andhra Pradesh	122

LIST OF TABLES

S.No.	Description	Page No.
Table 3.1	City Population Size and Per Capita External Bus Trip Rate (PCEBTR)	9
Table 3.2	Level of Service in different Flow Conditions	11
Table 3.3	Decision Matrix for Bus Port Location	13
Table 3.4	Bus Port Location Strategy	13
Table 3.5	Process of Conducting Traffic Surveys	16
Table 3.6	Forecast Techniques	22
Table 4.1	Dwell Time for Single and Multi-Door Bus Entry	23
Table 4.2	Default Values of per person Alighting and Boarding Times	24
Table 4.3	Estimation of Number of Bus Bays - Input Values (where Primary Data is unavailable)	25
Table 4.4	Estimation of Number of Boarding Bays (where Primary Data is unavailable)	25
Table 4.5	Estimation of Number of Alighting Bays (where Primary Data is unavailable)	26
Table 4.6	Estimation of Number of Idle Parking Bays (where Primary Data is unavailable)	26
Table 4.7	Estimation of Number of Bus Bays - Input Values (where Primary Data is available)	26
Table 4.8	Estimation of Number of Boarding Bays (where Primary Data is available)	27
Table 4.9	Estimation of Number of Idle Parking Bays (where Primary Data is available)	27
Table 4.10	Guidelines for Segregated Boarding & Alighting bays	28
Table 4.11	Guideline Dimensions for Parallel Loading Berths	29
Table 4.12	Guideline Dimensions for Shallow Sawtooth Loading Berths	30
Table 4.13	Bus Loading Berths for various Modules of Length	31
Table 4.14	Design Dimensions from Maximum Values of Buses in use in India	35
Table 4.15	Standard Dimension for Bus Accelerating and Decelerating Lanes	36
Table 4.16	Geometries of Bus Bays	38
Table 4.17	Types of Bus Loading Configurations Alighting Bays	39
Table 5.1	Parameters for Calculating Efficiency of 'Time of Access' between Modes	52
Table 5.2	Level of Service for Time of Interchange between Modes	52

S.No.	Description	Page No.
Table 5.3	Level of Service for Ease of Access through Wayfinding	53
Table 5.4	Level of Service for Ease of Access through Grade Separation	54
Table 5.5	Level of Service for Multimodal Integration	55
Table 5.6	Defining CCTV System Requirements	62
Table 5.7	Fire Fighting Measures	64
Table 5.8	Recommended Illumination Levels for various Areas in the Bus Port	66
Table 6.1	Bus Port Components for 10 Bus Bay Port	70
Table 6.2	Levels of Service	72
Table 6.3	Calculations for Stairway Width and Queuing Area	73
Table 6.4	Escalator Capacity	73
Table 7.1	Maintenance Standards - Bus Circulation, Parking and Approach Roads	84
Table 7.2	Maintenance Standards - Passenger Concourse, Subways & Corridor	86
Table 7.3	Periodic Maintenance	87
Table 8.1	Semi-Automatic vs Fully Automatic Parking	89
Table 8.2	Area Norms per ECS (Minimum)	91
Table 8.3	Site Reconnaissance	93
Table 8.4	LOS for a Mid-Block Section	96
Table 8.5	LOS for an Intersection	97
Table 8.6	Required Lux Levels	110
Table 8.7	Planning and Design Parameters for Evaluation of Bus Port	116
Table 8.8	Qualitative Parameters for Evaluation of Passenger Amenities	117
Table 8.9	Rating of Bus Port	118
Table 9.1	Various Design Parameters considered for Faridabad Bus Port	119
Table 9.2	Various Design Parameters considered for Kolkata Bus Port	120
Table 9.3	Various Design Parameters considered for Vijayawada Bus Port	121

PERSONNEL OF THE HIGHWAYS SPECIFICATIONS AND STANDARDS COMMITTEE

(As on 04.06.2022)

1	Nirmal, S.K. (Convenor)	Additional Director General-Nodal, Ministry of Road Transport and Highways, New Delhi
2	Sarangi, D. (Co-Convenor)	Additional Director General (S&R), Ministry of Road Transport and Highways, New Delhi
3	The Chief Engineer (R) (Member-Secretary)	S, R & T, Ministry of Road Transport and Highways, New Delhi

Members

4	Chandra, Dr. Satish	Professor, IIT Roorkee
5	Bose, Dr. Sunil	Head (Retd.), FP Division, Central Road Research Institute, New Delhi
6	Gupta, D.P.	DG(RD) & AS (Retd.), Ministry of Surface Transport, New Delhi
7	Jain, R.K.	Chief Engineer (Retd.), PWD Haryana
8	Joshi, C.P.	Secretary (Retd.), Maharashtra PWD and OSD & IE, MSRDCL, Mumbai
9	Kapila, K.K.	Chairman & Managing Director, ICT Pvt. Ltd., New Delhi
10	Katare, P.K.	Engineer-in-Chief (Retd.), Urban Development and Housing Department, Madhya Pradesh
11	Kumar, Anil	Additional Director General (Retd.), Border Roads Organisation, New Delhi
12	Kumar, Dr. Mahesh	Engineer-in-Chief (Retd.), PWD (B&R) Haryana
13	Nirmal, S.K.	Additional Director General-Nodal, Ministry of Road Transport and Highways & Secretary General, Indian Roads Congress, New Delhi
14	Pandey, I.K.	DG(RD) & SS (Retd.), Ministry of Road Transport and Highways, New Delhi
15	Pandey, R.K.	Member (Projects), National Highways Authority of India, New Delhi
16	Parida, Prof. (Dr.) M.	Deputy Director, Indian Institute of Technology, Roorkee
17	Rawat, M.S.	Executive Director, AECOM India Pvt. Ltd.
18	Shrivastava, A.K.	Additional Director General (Retd.), Ministry of Road Transport and Highways, New Delhi
19	Singh, Nirmaljit	DG(RD) & SS (Retd.), Ministry of Road Transport and Highways, New Delhi
20	Singh, Prabhakar	DG (Retd.), Central Public Works Department, Ministry of Housing and Urban Affairs, New Delhi
21	Sinha, A.V.	DG(RD) & SS (Retd.), Ministry of Road Transport and Highways, New Delhi
22	The Chief Engineer (Civil) (Rathore, A.S.)	Border Roads Organisation, New Delhi
23	The Chief Engineer (NH) (Meghwal, D.R.)	Public Works Department, Rajasthan
24	The Chief Engineer (Shelar, S.G.)	Public Works Department, Maharashtra
25	The Director General (Sharma, Shailendra)	Central Public Works Department, New Delhi

26	The Director (Tech.) (Pradhan, B.C.)	National Rural Infrastructure Development Agency, New Delhi
27	The Engineer-in-Chief (Choudhary, H.P.)	Road Construction Department, Bihar
28	The Engineer-in-Chief (Samal, P.K.)	Public Works Department, Odisha
29	The Executive Director (Blah, W.)	National Highways and Infrastructure Development Corporation Ltd., New Delhi
30	The Member (Tech.) (Singh, Mahabir)	National Highways Authority of India, New Delhi
31	The Professor (Ahmed, Dr. Mokaddes Ali)	National Institute of Technology, Silchar
32	The Professor (Das, Dr. Animesh)	Indian Institute of Technology, Kanpur
33	The Professor (Reddy, Dr. K. Sudhakar)	Indian Institute of Technology, Kharagpur
34	The Professor (Kumar, Dr. Praveen)	Indian Institute of Technology, Roorkee
35	The Professor (Swami, Dr. B.L.)	Malaviya National Institute of Technology, Jaipur
36	The Secretary (Vasava, S.B.)	Roads and Buildings Department, Gujarat
37	The Superintending Engineer (Sangma, C.N.)	Public Works Department, Meghalaya
38	Wasson, Ashok	Member (Tech.) (Retd.), National Highways Authority of India, New Delhi

Corresponding Members

1	Chandrasekhar, Dr. B.P.	Director (Retd.), National Rural Roads Development Agency, New Delhi
2	Gairola, Col. Pradeep	General Manager, National Highways & Infrastructure Development Corporation Ltd.
3	Nashikkar, J.T.	Secretary (Retd.), Public Works Department, Maharashtra
4	Rao, Prof. (Dr.) K.V. Krishna	Professor, Indian Institute of Technology, Bombay
5	Veeraragavan, Prof. (Dr.) A.	Professor, Indian Institute of Technology, Madras

Ex-Officio Members

1	President, Indian Roads Congress	(Joshi, C.P.), Secretary (Retd.), PWD Maharashtra and OSD & IE, MSRDCL, Mumbai
2	Honorary Treasurer, Indian Roads Congress	(Nirmal, S.K.), Additional Director General-Nodal, Ministry of Road Transport and Highways, New Delhi
3	Secretary General, Indian Roads Congress	Nirmal, S.K.

GUIDELINES FOR DEVELOPMENT OF BUS PORTS IN INDIA

1. INTRODUCTION

The Ministry of Road Transport & Highways have formulated a scheme for Development of Bus Ports in States/UTs and intends to provide safe, convenient, user-friendly boarding and de-boarding points and world class amenities for the passengers thus improving passenger experience with public bus transportation. Subsequently, Ministry has developed comprehensive set of Guidelines/Report covering various aspects of Bus Port Design. The Transport Wing of Ministry of Road Transport & Highways vide letter dated 26.06.2020 requested IRC to formalize the Guidelines for Development of Bus Ports in India for adoption by State/City Transport Authorities, Urban Local Bodies etc. Accordingly, the task was assigned to Urban Roads & Streets Committee (H-8) of IRC. The H-8 Committee in its meeting held on 07.11.2020 deliberated the Ministry's Report on Bus Ports and constituted a subgroup comprising Dr. Ch. Ravi Sekhar as Subgroup Chairman, Dr. M. Parida, Shri D.P. Gupta, Shri Paresh Kumar Goel, Prof. (Dr.) Ankit Kathuria, Prof. (Dr.) Shubhajit Sadhukhan, Prof. Sairam Dasari, Shri Rajiv Sharma and Shri M. Bhushan Kumar to prepare the Guidelines. The draft prepared by the subgroup was discussed and deliberated during various meetings of the H-8 Committee and was finalized in H-8 Committee meeting held on 30.04.2022.

The composition of H-8 Committee is given below:

Parida, Prof. (Dr.) M.	.....	Convenor
Kumar, Dinesh	.....	Co-Convenor
Ravi Sekhar, Dr. Ch.	.....	Member-Secretary

Members

Agarwal, Dr. Anjlee	Thakar, Vikas
Bhatt, Amit	BRO (Reddy, P.H.)
Gupta, D.P.	CPWD (Gupta, S.K.)
Gupta, Uttam	IIT Bombay (Maji, Prof. (Dr.) A.)
Kumar, Anant	IIT Kharagpur (Goswami, Prof. (Dr.) A.K.)
Kumar, Dr. Pawan	NHIDCL (Grover, Pankaj)
Rao, Prof. (Dr.) K.R.	NIT Warangal (Shankar, Prof. (Dr.) K.V.R. Ravi)
Rao, Prof. (Dr.) K.V.K.	PWD Maharashtra (Mungilwar, S.G.)
Rastogi, Prof. (Dr.) Rajat	PWD Odisha (Giri, A.K.)
Sharan, G.	PWD UP (Banga, J.K.)
Singh, Nirmaljit	

Corresponding Members

Navghare, P.D.	Sharma, Rajiv
Sharma, Kuldeep	

Ex-Officio Members

President, Indian Roads Congress	(Joshi, C.P.), Secretary (Retd.), PWD Maharashtra and OSD & IE, MSRDCL, Mumbai
Honorary Treasurer, Indian Roads Congress	(Nirmal, S.K.), Additional Director General-Nodal, Ministry of Road Transport and Highways
Secretary General, Indian Roads Congress	Nirmal, S.K.

The revised draft document was placed before the Highways Specifications and Standards Committee (HSS) in its meeting held on 04.06.2022. The HSS Committee approved this document subject to suitably incorporating written and verbal comments received and also recommended it for placing before the meetings of Executive Committee (EC) and Council. The EC in its meeting held on 16.06.2022 approved the draft document for placing before the Council. The 222nd Mid-Term Council in its meeting held on 17th – 18th June, 2022 at Shillong (Meghalaya) considered and approved "Guidelines for Development of Bus Ports in India" for printing.

These Guidelines include various technical inputs related to the design like demography of the area, assessment of travel demand, future expansion of development and the outputs like site suitability, capacity assessment in terms of Bus Bay requirement, Bus Bay layout, Entry/Exit design, smooth circulation of traffic, Pick-up/Drop facilities, pedestrian dispersal facilities, bus movement parameters like turning radii, lane width, clearances etc.

1.1 Background

Cities in India have become engines of economic growth and are growing at a fast pace. Organized public transport is a key ingredient to sustain this economic growth. Public transport facilities and adjunct infrastructure need to be designed based on sound principles and guidelines to enhance its efficiency and reliability. These guidelines also significantly focus on enhancement of the quality of services available to the passengers in terms of accessibility, user experience inside and outside the bus port while contributing towards development of the city transport infrastructure.

1.2 Purpose of Bus Ports

A bus port is a transport infrastructure facility where intercity or intra-city buses pick up or drop off the passengers and typically have several routes terminating/originating at these locations. It is also the place where passengers can interchange between buses and other modes of transport. Bus port is also a confluence point in a city/town due to commercial developments that get generated in the vicinity and Public Private Partnerships (PPPs) are a way to capture at least some of the commercial benefits. Thus, bus port form an important interface between public transport and passengers well beyond a place of interchange.

1.3 Objectives of Bus Port Planning

Bus Ports are an indispensable element in the operation of bus services. Their design and location affect the efficiency of a transport system and its impact on other road users. Most bus ports in India are regarded as landmarks for the city, but at no time this prestige outweigh their practicality or efficiency and utilitarian design.

Bus port planning should be aimed at integrated development, with commercial areas within and outside it, to serve the immediate needs of travelers while creating a precedent for the redevelopment of the surrounding areas. Integration with other modes of transport, connectivity provided by the local transit systems to allow ease of access and the needs of localized traffic and pedestrian circulation should be given a lot of importance in the planning of the site. Some of the major areas of concern with each stakeholder are illustrated in **Fig. 1.1**.

Fig. 1.1 Stakeholders Requirements

Based on the user groups, the master planning area of the bus port can be easily divided into the following broad components:

(i) Passengers

(ii) Bus Operators/Drivers

(iii) Feeders transport services

Each of the above areas has a different requirement and needs different parameters for planning and design. The ease of use of the facility by the end users shall dictate the success or the failure of the facility. The diagram below presents the areas of engagement of the aforementioned users of the bus port: The bus port planning considerations associated with each user group are presented in the **Figs. 1.2, 1.3** and **1.4**.

Fig. 1.2 Bus Port Planning considerations from the Passenger Perspective

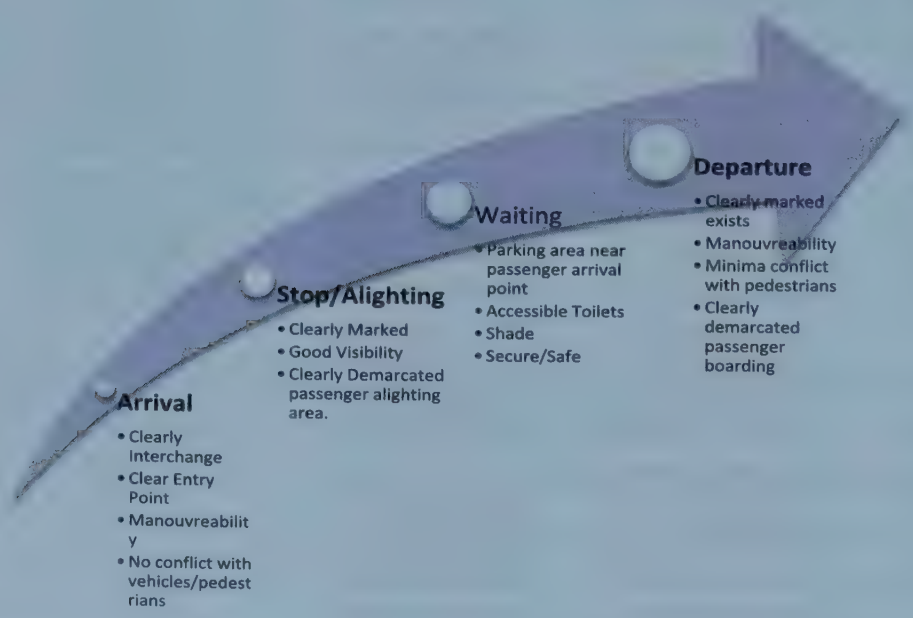


Fig. 1.3 Bus Port Planning Considerations from a Feeder Transport Service Perspective

Fig.1.4 Bus Port Planning Considerations from Operator/Driver Perspective

1.4 The Objective of the Bus Port Guidelines

The purpose of these guidelines is to facilitate State & City Transport Authorities, Urban Local Bodies (ULBs), State Governments, Planners, Engineers and Architects in designing the bus ports in India. These guidelines will help in the capacity building of the manpower working in the institutions mentioned above.

2. PLANNING PRINCIPLES

2.1 Introduction to Planning Principles

Bus Port planning refers to the organizational stage of the design process. Site planning generally begins by assessing a potential site for development through site analysis. The eight-step process to be followed for planning of a bus port is enumerated below.

Principle 1: Location of Bus Port

Traditionally, bus port in a town/city is located at the city centre and as the density at the city centre increases with elapse of time, the holding capacity of the network around bus port reduces. The increasing real estate value at the city centre further increases the cost of any proposed expansion of existing bus port and related facilities. It therefore becomes essential that bus ports are located with adequate network capacity. In addition, cities need to explore multiple bus port either due to city expansion or due to saturation of holding capacity of existing bus port.

Principle 2: Plan for Ease of Bus Maneuverability

The bus maneuverability in the proposed and exiting, bus port site should be the starting point for designing movement through the site. This can be undertaken by the following:

- Use left-in and left-out concept with one way flow for buses and avoid conflict points with other modes of transport with special care taken to safely segregate pedestrian and non-motorized transit modes.

- Keep the access roads to the bus Port short and direct avoiding long and circuitous connector roads.
- Prioritize and facilitate safe and easy merging and diverging of buses into and from the major thoroughfare through the necessary geometrical design or if required signalization.

Principle 3: Prioritize Passenger/Pedestrian Movement with Minimum Conflict Points

The third principle is prioritizing pedestrian access because all modes finally become the pedestrian mode, to access the bus port i.e. whether the passenger arrives by an auto rickshaw or a personal car, he/she will be finally accessing the bus port as a pedestrian. Pedestrian movement should be clearly facilitated at entry and exit points within and from outside the site as these are the most common spaces of conflict with other movement modes.

Principle 4: Passenger Entry Points should be coupled with appropriately Designed Exterior Spaces

The entrances to the bus port should be coupled with well-designed exterior spaces which not only provide a proper and noticeable entry into the bus port, but also helps in creating an attractive and active public realm. The design of these exterior spaces is not only to receive and accommodate passengers, but also to incorporate all formal and informal activities that create public spaces.

Principle 5: Prioritize Sustainable and More Efficient Modes of Transport and Minimize Conflict

Fifth, relates to multi modal integration. More efficient and sustainable modes of movement should be prioritized. This means that these modes should be placed close to the bus port as much Non-motorized Transport. The shared auto, auto rickshaw, associated principle private mini buses with these modes of movement, personalized motorized modes should not conflict (cars, motorbikes) with each other or have minimal conflict points. The spatial efficiency of a bus port is critically dependent on the ease of interface to other modes of movement.

Principle 6: Ensure Pedestrian Zone Closest to the Bus Port with Fastest Modes Away

Sixth, the general principle that should be considered while designing circulation is that the bus port building can be thought of as being surrounded by a number of distinct zones. The zone immediately around the bus port building will have the slowest speeds with the fastest speeds furthest away from the bus port building. The movement in the slowest zone will be primarily oriented towards accommodating the slow speed of the pedestrian. This means that even if there is movement of vehicles close to this zone, traffic calming measures will have to be used to avoid danger to the pedestrian.

Principle 7: Ensure Long, Active and Visually Transparent Public/Street Edge for Bus Port

The sixth principle is to ensure that site planning results in developing a bus port which has its longest edges towards the public street edge. Site planning should ensure that an active public realm is produced, coordinating both the bus port building to have active programs and visually transparent edges towards the public edge as well as designing the exterior space itself with landscape, seating, lighting and so on.

Principle 8: Design Grading and Vegetation to Minimize Surface Water Runoff

The eighth principle relates to designing the grading and vegetation on the site. Bus Port conventionally result in a large area of non-permeable surface that create large amounts of run off or water logging problems. It is critical therefore to create a grading plan which will determine the paths in which water will run and collect. The design of vegetation coordinated with grading is to ensure that such pockets of vegetation ensure percolation of water along with the traditional benefits of vegetation like shade and lowering of temperatures.

2.2 Bus Port Function

The bus port can function differently in different cities based on the demand needs, routing pattern and connectivity requirements. Hierarchy of bus ports can be Global (International), Regional and City level/local level based on destinations being served from the bus port

(i) International Bus Port

International bus port are recommended at those cities which have bus connectivity with neighboring countries such as Pakistan, Nepal, Bhutan, Bangladesh and Myanmar etc. Delhi and Kolkata have international bus ports with buses operating from Delhi to Lahore and Kathmandu and from Kolkata to Dhaka. International bus ports could have additional functions similar to that of an airport such as immigration and customs check etc. These international activities are recommended to be segregated from other bus port activities. With expectations of improving bilateral ties with neighboring countries; the cities in proximity to the international borders could plan for international bus ports or enhance their existing capacities.

(ii) Interstate and Intercity Bus Port

These bus ports connect cities with other cities and region. In some cities, intercity bus port also act as regional hubs where road network imparts a strategic advantage to a specific location. The major factor of a regional or intercity bus port is the population within the city and its interaction with other cities in the region or neighboring state, location of city and routing pattern.

To decide for interstate & intercity bus ports, parameters to be reviewed are the passenger travel pattern of the given city w.r.t region/towns, location of city which could potentially promote aggregation of multiple routes.

(iii) Mofussil Bus Port

These bus ports connect cities with other nearby villages and cities. In some cities, mofussil bus services also act as regional hubs where road network imparts a strategic advantage to a specific location.

(iv) City Level/Local Bus Port

These bus ports serve requirement of intra city public transport needs. The city size, public transport travel demand, route pattern, travel pattern define the type and number of bus port requirement for a city/town. Modal share and average trip length within city limits can be considered as other parameter to define the city/local bus port. Higher the modal share of buses (Public transport) and IPT, larger and more numerous would the need for local bus ports.

Based on various characteristics, cities can decide on function of bus port and then plan subsequent planning activity. Once the function of the bus port is identified the next step is the process to be followed for understanding the bus port requirements, need and locational strategy which is as follows.

3. ASSESSMENT OF REGIONAL TRAVEL DEMAND

The need for a city can be assessed through the understanding of the functions, demographics, travel demand for planning horizon and deciding on optimum bus port size which could be accommodated at one location without causing much adverse impact on surrounding network (holding capacity).

To understand and estimate the need for a bus port is dependent on several factors and the key factors are described in the following paragraphs:

Assess Travel Demand	Intercity per Capita Trip Rate
	Planning Horizon
	City's Spatial Structure

3.1 Intercity Per Capita (External) Bus Trip Rate (PCEBTR)

The first step is to identify the number of regional and inter-state trip demand based on various parameters. The parameters shall be assessed from the analysis of data obtained from various secondary sources and/or by conducting primary surveys by city authorities. Per Capita Trip Rate (PCTR) indicates the mobility of the people for particular type of travel. It is the ratio of total number of trips made by a particular mode of transport to the total surveyed population i.e. Higher the PCTR values of a mode of transport implies that large number of trips are being made by that particular mode of transport.

In this case, data to be sought is Per Capita External Bus Trip Rate (PCEBTR) which will provide the number of regional and inter-state trips from the city. The parameters that affect the PCEBTR

for a given city includes the regional economies that drives more trips from the given city to other regional cities. If the city or a town is considered as regional hub or even when the city is in proximity to a regional hub, higher PCTR is expected. The intercity PCEBTR could vary based on alternative modes (railway), socio-economic status of population etc.

It is therefore recommended that cities develop their own PCTR based on various travel surveys. In smaller cities and where existing data may be sufficient supported by CMP/CDP, survey at existing bus ports/informal points of boarding/alighting, other modes provide the best solution to assess the demand for Bus Port.

There are three methods to estimate the intercity bus travel demand and are as follows:

(i) Direct Demand: based on city size

(ii) Traffic and Travel surveys at existing port/regional bus stop locations

(iii) Secondary reports: CMP/CDP/Master Plan reports

In case no information is available then direct demand method can be adopted in cities then values from **Table 3.1** given below could be adopted for broad assessment of intercity demand.

Table 3.1 City Population Size and Per Capita External Bus Trip Rate (PCEBTR)

Population Size	PCEBTR
Below 0.5 million	0.030
0.5 to 1 million	0.035
1.0 to 3.0 million	0.040
3.0 to 5.0 million	0.050
above 5.0 million	0.060

3.2 Planning Horizon

The travel demand shall be forecasted for the planning year (horizon year) till which the bus port is intended to cater for demand. Planning horizon shall have direct impact on the number and sizing of bus port requirement for any city/town.

In a Master Plan or Comprehensive Mobility Plan (CMP) is prepared for a city, horizon year shall be defined for any demand forecast. The forecast of population, mode-wise trips, and bus port needs shall be provided for the horizon years and the same planning period may be considered for planning of bus ports due to availability of data related to bus port planning. In India, the Master Plans and CMPs for cities and towns are usually prepared for a period of 20 years.

3.3 City Spatial Structure

Bus Port size and the number of bus ports in a city depend upon the spatial structure of the city. City spatial structure and the road network pattern explain the access connections with in

the city and the future growth direction of the city. Spatial growth and density levels play a vital role to take decision on number of bus port required in a city. Linear development with a grid transport network will have a very less access to the bus port and also very less possible to have a bi-directional oriented bus ports when compared to the circular development with a ring radial network. The size and location of the bus port also depends on the density of the city. In cities with higher densities, availability of land is very less in the city centre, whereas moving away from the city centre will increase the availability of the land, where bi-directional oriented bus ports concept can be opted in that condition which would increase the number of bus ports.

3.4 Assessment of Gross Bus Port Demand

From the data analysis of the filed surveys and secondary data, estimation of the passenger demand and number of required buses and number of required bus bays is undertaken. The process of calculation is presented below.

Number of required Bus Bays	=	Number of buses in peak hour/handling capacity of one bus bay
Passenger Demand	=	Number of Buses X Occupancy factor

In case the traffic survey data is not available, it can be undertaken as follows:

Passenger Demand	=	Bus Port $PCTR_{city\ size}$ X Population of the city in the horizon year
Number of required Buses	=	Passenger Demand/ Occupancy
Number of required Bus Bays	=	Number of buses in peak hour/handling capacity of one bus bay

3.5 Assessment of Number of Bus Ports

Based on above analysis, need for another bus port in any city can be assessed. Existing bus port capacity will decide the need of an additional bus port in the city for the horizon period. If the number of required bus bays in the existing bus port is more than the existing number of bus bays than expansion of existing bus port is required.

In case, the existing bus port cannot be expanded than additional bus port needs to be developed.

At times, other local conditions such as congestion, encroachments onto the access road etc., trip efficiency for buses to access the location also determines the need for an additional bus port. It is therefore important that capacity of external network shall be determined while deciding for bus port expansion. As a broad norm, it is recommended that access be at the very least through a sub-arterial undivided road with a capacity of 2400 PCUs per hour as specified by IRC:106.

The main indicator that can be used to assess the parameter is the Level of Service of the road. The road network around bus port shall maintain Level of Service C for maintaining smooth movement. The qualitative and quantitative definition of the LoS is mentioned in the **Table 3.2** below which is referred from the IRC:64.

Table 3.2 Level of Service in different Flow Conditions

Level of service	Description	V/C
A	Free flow condition; Freedom to manoeuvre is high; comfort and convenience of users is excellent. Average travel speed usually about 90% of the free flow speed for the arterial case	0.35
B	Stable flow condition; Comfort and convenience is slightly lower than LoS A; Other vehicles in the traffic stream starts affecting individual behaviour; Average travel speeds are usually about 70% of the free flow speed	0.55
C	Stable flow condition; vehicle manoeuvring requires substantial vigilance; Other vehicles in the traffic stream significantly affects individual behaviour; Average travel speeds are usually about 50% of the free flow speed	0.77
D	Limit of stable flow condition and conditions approaching unstable flow; drivers are severely restricted in their freedom to select desired speed and manoeuvre within the traffic stream; Average travel speeds are usually about 40% of the free flow speed	0.92
E	Traffic volumes are close to Capacity; Comfort and Convenience are extremely poor; small increase in traffic cause breakdown of traffic stream; Average travel speeds are usually one third of the free flow speed	1
F	Represents forced or breakdown flow; Queues form behind such location; Queues are characterized by stop and go waves; The average travel speeds are between 25% and 33% of the free flow speed. Traffic volumes are beyond the capacity levels	Above 1.00

3.6 Selection of Bus Port Location

Transit nodes have always been places of central importance in the structure of a city through which people orient and identify themselves. The key in this role is the location of the transit nodes. As evidenced by the locations of bus ports, these have generally been in the centre of the city that allows it to not only serve its role in terms of place making but also satisfying ideal transit requirements of even dispersal to the city while doubling as an interchange point.

However, as cities have developed in size and population, practical issues of land availability and congestion adversely affecting accessibility has made newer transit nodes to be relegated to the outer fringes of the city.

3.7 Identification of Bus Port Location

The processes that may be followed to arrive at the ideal location for the bus port are given in **Fig. 3.1**:

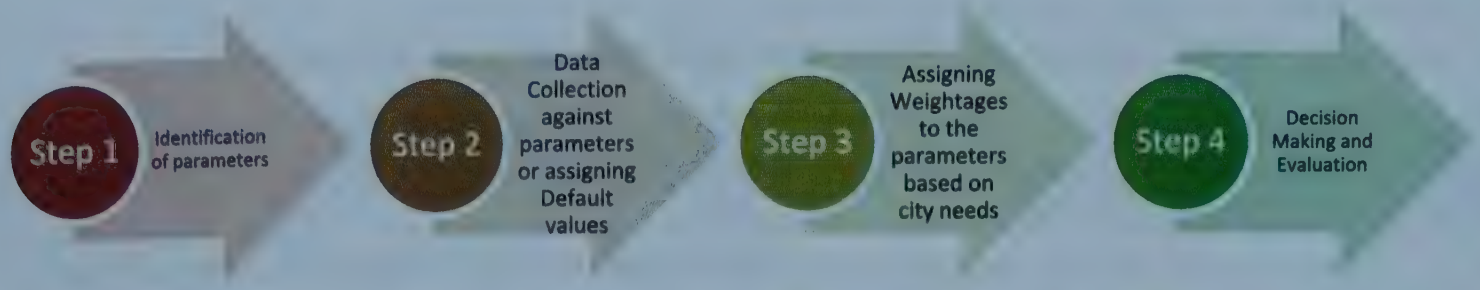

Step 1
Identification of parameters
Step 2
Data Collection against parameters or assigning Default values
Step 3
Assigning Weightages to the parameters based on city needs
Step 4
Decision Making and Evaluation

Fig. 3.1 Flow Chart for Identification of Bus Port Location

3.7.1 *Critical Parameters*

There are a number of considerations in deciding the best location. The location should be where routes should logically connect or terminate, as determined by passenger demand patterns. If the bus port is used as an intermediate stopping point on routes passing through, it should be conveniently located for passengers joining or leaving vehicles. New bus ports are also located outside central areas to avoid high land costs and congestion. But, this shall be conflicting with increasing dispersal trip length within the city which causes inconvenience to users.

The parameters can have different dimensions given in **Fig. 3.2**:

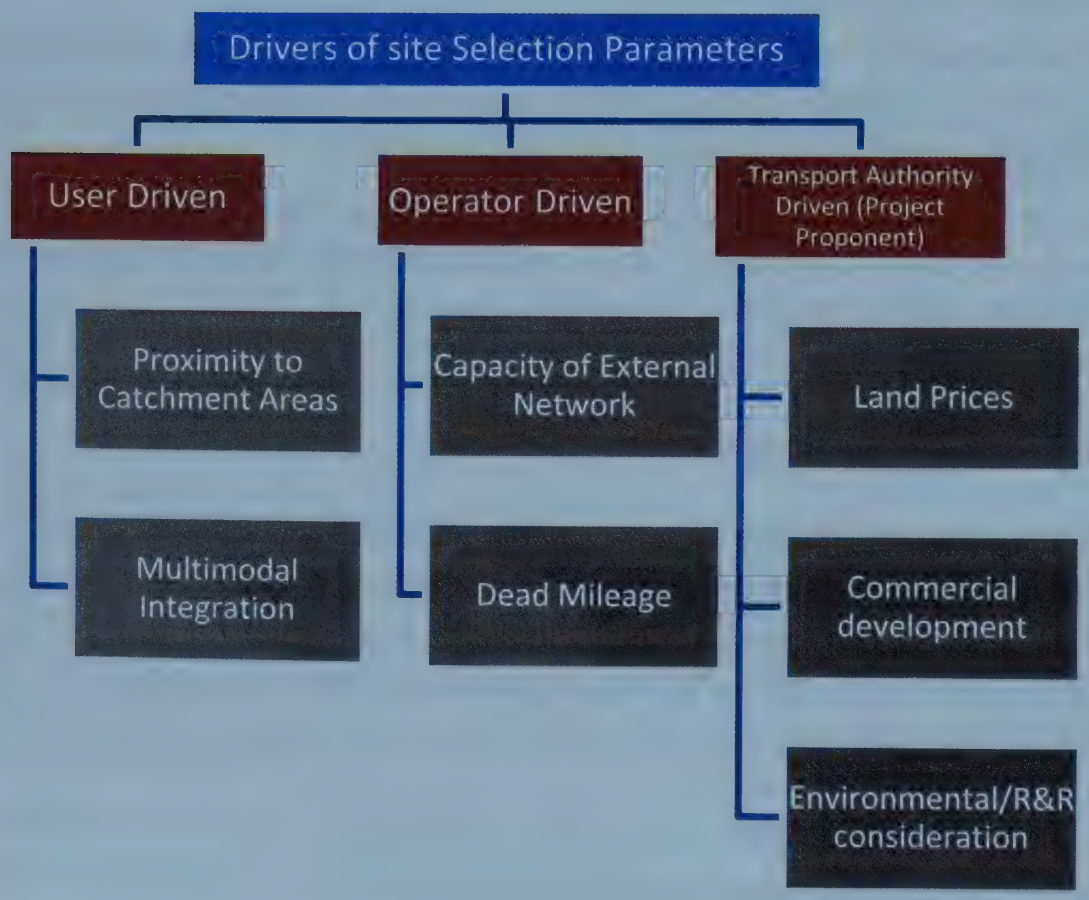


Fig. 3.2 Site Selection Parameters - Drivers

To determine the location for a new bus port, the following indicative criteria are considered. Depending on the project objectives and complexity the criteria can be adopted.

3.7.2 *Decision Matrix*

A decision matrix may be developed for locational strategy based on the parameters and the default values estimated based on the primary surveys conducted at various bus ports in India. The various parameters are provided with the following weightages **(Table 3.3)**:

Table 3.3 Decision Matrix for Bus Port Location

SN	Parameters	Determinant	Weightage*
1	Proximity to Catchment Areas	Average Trip Length of Passenger (km)	25%
		Passengers within City	
2	Multimodal Integration	Other Modes within walking distances	15%
3	Capacity of External Network	Level of Service	25%
4	Land Prices	Value of land per acre	5%
5	Commercial development Potential	Lease rentals of commercial area per sqm	5%
6	Environmental/R&R Consideration	Cost of mitigation measures	25%
	Total		100%

(*) - The weightages are indicative and may be fine-tuned by the transport planner based on the surveys and local conditions.

The weightage may differ from city to city based on the issues in availing land for bus port. The default scores for each of the indicators of each parameter are provided in **Table 3.4**:

Table 3.4 Bus Port Location Strategy

1	Distance from catchments (Average Trip Length of Passenger within City)	Points
(i)	< 2.5 Km	10
(ii)	2.5 - 5 Km	8
(iii)	5 - 10 Km	6
(iv)	10 - 15 Km	4
(v)	> 15 Km	2
	Location Score based on this parameter	**8**
2	**Scope of Multimodal Integration (Other Modes within walking distances)**	
(i)	Rail, MRTS, City Bus & IPT	10
(ii)	Rail, City Bus & IPT	8
(iii)	City Bus & IPT	6
(iv)	IPT	4
(v)	No other modes available	2
	Location Score based on this parameter	**8**

3	**Proximity of the Land with the Bus flow**	
(i)	More than 60% of bus trips	10
(ii)	40% - 60%	7.5
(iii)	20% - 40%	5
(iv)	Less than 20%	2.5
	Location Score based on this parameter	**10**
4	**Land Price/Real Estate Value**	
(i)	Very Low	10
(ii)	Low	8
(iii)	Moderate	6
(iv)	High	4
(v)	Very high	2
	Location Score based on this parameter	**6**
5	**Commercial Development potential/TOD Potential**	
(i)	Very high	10
(ii)	High	8
(iii)	Medium	6
(iv)	Low	4
(v)	No Potential	2
	Location Score based on this parameter	**8**
6	**Environmental/R&R Consideration**	
(i)	Very low impact	10
(ii)	Low impact	8
(iii)	Medium impact	6
(iv)	High impact	4
(v)	Very high impact	2
	Location Score based on this parameter	**6**

3.8 Capacity Assessment

3.8.1 *Introduction*

Assessment of infrastructure is critical for successful development of Bus Port. Correct assessment leads to building with relevant features and facilities to optimize cost and revenue for long term sustainability of any Bus Port.

Bus Port infrastructure can be grouped in the following manner **(Fig. 3.3)**:

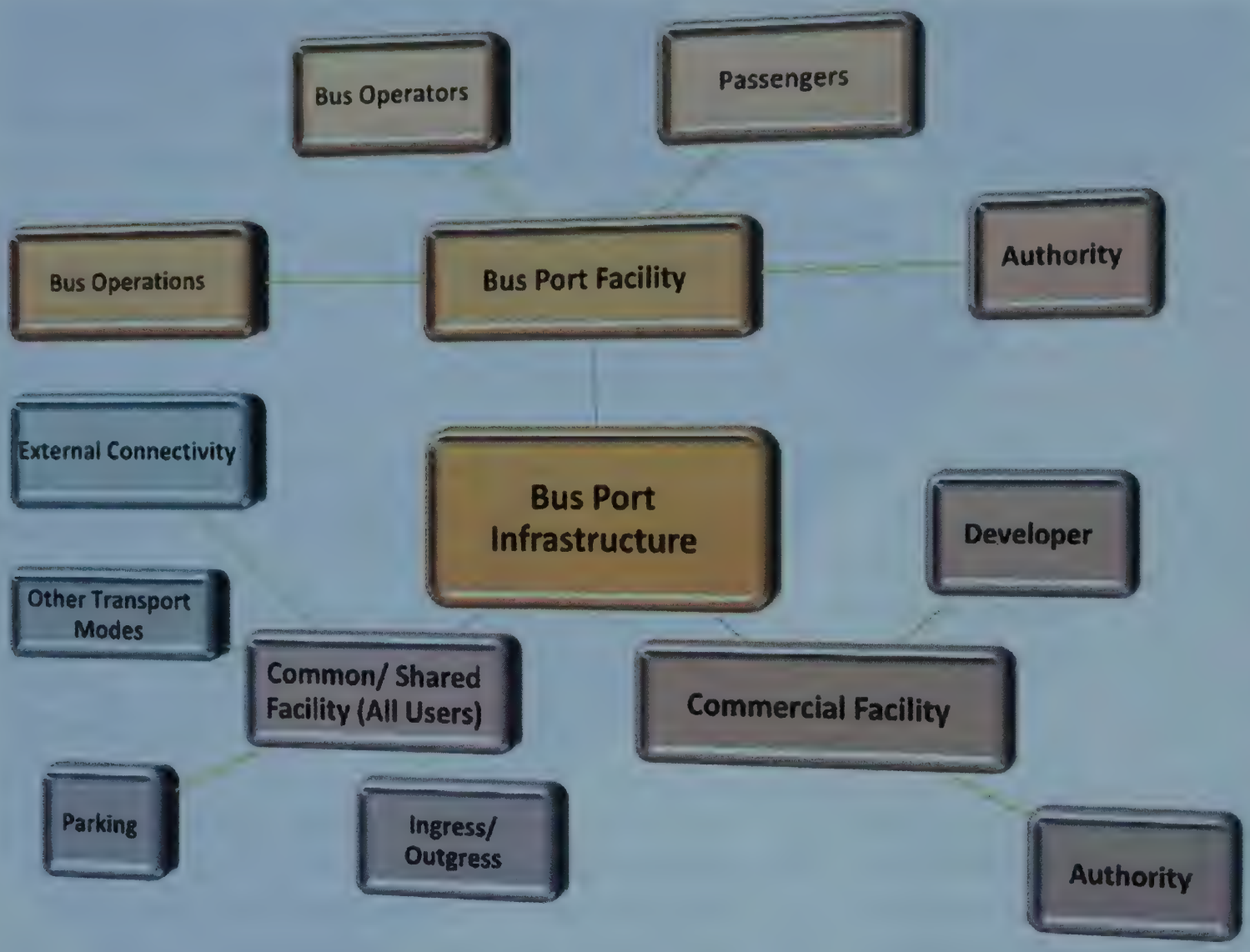


Fig. 3.3 Bus Port Infrastructure

Capacity requirement for design needs to be assessed for each of the aforesaid, since designs, estimates, implementation system; financial provisions are made based on the projected demand for ultimate success of project.

3.8.2 *Capacity Assessment for Bus Port Facility*

Demand assessment is a comprehensive review of all the new developments that will generate trips on the existing transport network, either by car, commercial vehicle, cycling, walking or public transport. In cases where a proposed development (bus port) is of a size or type that would generate significant additional trips on adjoining transport infrastructure, this additional demand may necessitate changes.

3.8.3 *Process Traffic & Transport Surveys and Secondary Data Collection*

Conducting traffic surveys is a pre-requisite for efficient demand assessment & planning of bus ports. The process of conducting traffic surveys can be summarized into the following steps **(Table 3.5)**:

Table 3.5 Process of Conducting Traffic Surveys

Name of the Survey	Purpose	Output	Survey Duration
Bus Count including pass through buses	To estimate bus demand, characteristics	• Daily/Average bus entering/exiting • Peak hour Characteristics • Dwell Time	24 hours
Passenger Head count	To estimate daily passenger volume and their characteristics (Boarding & Alighting)	Daily & Peak Passenger volume	24 hours
Commuter Arrival and Dispersal Pattern	To determine commuter travel characteristics at bus port	Modes used for Arrival and Dispersal	• 24 hours • Sample Size 500 • A group of 4 persons to be counted as 4 samples
Omni Bus Operators	To understand bus demand, characteristics and facilities required	• Daily/Average bus entering/exiting and pass-through buses Peak hours • Daily variations Indicative Dwell Time • Facilities required like ticket counters, crew rest room, depot/maintenance/ workshop facilities etc.	• Interview based • 5 - 10 operators
Private Bus Operators	To understand bus demand, characteristics and facilities required	• Daily/Average bus entering/exiting and pass-through buses Peak hours • Daily variations Indicative Dwell Time • Facilities required like ticket counters, crew rest room, depot/maintenance/ workshop facilities etc	
Government Bus Operator	To understand facilities required	Facilities required like ticket counters, crew rest room, depot/maintenance/ workshop facilities, etc.	
Commuter Perspective Survey	To assess the commuter perspective	• Travel purpose • Time spent at Bus Port • Mode Choice (bus, 4 wheeler, 2 wheeler, auto, paratransit) • Facilities preference like waiting room, seating arrangements, public conveniences etc.	• 24 hours • Sample Size 500

Secondary data has to be collected which will be helpful in strengthening the analysis & planning parameters. This shall include the following data:

(i) Previous studies, reports such as Comprehensive Mobility Plan (CMP) and Master Plan/ Development plans prepared for the city. This shall provide with basic data such as the per capita trip rates and also the intercity and intra city trip rates within the existing ports

(ii) Existing and proposed transport infrastructure: existing and proposed Intercity Railway/ Commuter service/MRTS/Monorail/LRT/BRT and other transit lines and their proposals from Reports (DPRs, TEFR etc.)

(iii) Bus port related data such as:

- Bus Operator details (Types of Operators like Transport Undertaking or Private Operator, No. of buses & trips etc.)
- Ticket sold
- Type of service
- Existing Time Table
- Port Area

The above-mentioned data only gives an idea for the type of data is required; the actual data requirement might vary from site to site. For example: If a port is to be located in a town where mela/ festive seasons lead to significant increase in demand, the demand for the same should be determined from

3.8.4 *Transport Demand Forecasting Methods*

Demand prediction for any major infrastructure project is critical and is required for varied reasons. The foremost reason is to plan or design the transport infrastructure to meet the future demand requirements for the horizon period under consideration. Forecasts also provide benchmarks for proper design and efficient transportation system operation. Transportation forecasts are fundamentally important inputs in developing infrastructure – from developing overall transportation policy to planning studies to the engineering design of specific projects. Some of the applications of forecast information include:

- Development of infrastructure capacity and design calculations (e.g. the operations of an existing or proposed bus port)
- Estimation of the financial and/or social viability of projects (e.g. developing benefit-cost analysis and/or social impact assessments)

- Traffic Impact Assessment (TIA) of the transport infrastructure
- Calculation of environmental impacts, such as air and noise pollution
- Planning for the transport facility/operations

In all the above situations, the accuracy with which future traffic is predicted is of prime importance. There are different methods and software tools available for the transport demand estimation. And these forecasting techniques are also applicable in the estimation of bus port demand and thereby understanding the needs of the bus port in the horizon period.

For any traffic forecasting method, in general, there is a requirement of the data through which the analysis shall be done. The data requirement can be met by primary data collection obtained through traffic surveys and from secondary data collection obtained through review of past relevant reports and also from the operational data of the various transport facilities of similar nature like historical data from the bus ports in the present case.

Traffic growth is governed by a number of Economic factors (NSDP/GDP/PCI) and Demographic factors (Population, Age, Gender etc.). The requirements of the traffic forecasting are mentioned below.

(i) Collection of Primary Data and Base Traffic Estimates

The following primary survey are required to estimate base year traffic:

- Traffic surveys to estimate present demand
- Seasonal variation data to make adjustments
- Passenger interviews to find out the trip characteristics/travel pattern
- Land use and local network inventory

(ii) Collection of Secondary Data

The following secondary data is required to estimate growth factor to project horizon year traffic:

- Time series operational data of various transport facilities in similar nature
- Time series data of Socio economic indicators influencing the demand like GDP, NSDP, population and per capita income etc.
- Review of past study reports
- Studies relating to investments, improvements in the infrastructure in the project influence area & macro-economic reports (RBI, NCAER, WB, ADB etc.)

(iii) Selection of a proper Traffic Forecasting Technique/Method and Growth Rate Assessment

The following forecasting techniques can be considered to estimate growth rate:

- Objective of traffic forecasting
- List out factors affecting traffic growth
- Data availability
- Availability of resources (technical expertise, software etc.)
- Strength of the forecasting method

(iv) Transport Demand Forecasting Methods

This section lists out the different demand forecasting methods generally used by the transport practitioners across the world and the list is not limited to the below mentioned methods. Selection of a forecasting method is mainly based on the data and resource availability. The transport professionals may also undertake combinations of different methodologies to arrive at the consensus of the future demand depending on the project objectives like planning, bidding, operations etc.

- Time series methods
- Econometric model
- Judgmental methods
- Reference class

3.8.5 *Description of Demand Forecasting Methods*

(i) Time Series Method

Time series forecasting is used to forecast future events based on known past events to predict data points before they are measured. Past trend of a traffic growth is a indicative guide in determining the future trend. Past trends can be established from a variety of traffic growth indicators such as:

- Number of buses operated daily in past years
- Traffic flow from census
- Vehicle registration data

A comparison of the growth rates for each of the above will be useful. For establishing reliable growth rates, the data should be for a number of years. The best way to arrive at the rate of

growth is through a regression analysis. The formula expressing the compound rate of growth for traffic is:

$$P_n = P_o(1 + r)^n \qquad \text{Eq 3.1}$$

Where P_n = Traffic in the n^{th} year

P_o = Traffic in the base year n = Number of years

r = annual rate of growth of traffic

Taking logs on both sides, $log_e P_n = log_e P_o + n\ log_e(1+r)$ in the form of $Y = A_o + A_1 n$ *Eq 3.2*

Where $Y = log_e P_n$, $A_o = log_e P_o$ and $P_o = e^{A_o}$,

$A_1 = log_e(1+r)$, and $(1+r) = e^{A_1}$

The above equation can be established from a set of n values.

(ii) Econometric Method

Certain forecasting methods use the assumption that it is possible to identify the underlying factors that might influence the variable that is being forecast. For example, sales of umbrellas might be associated with weather conditions. If the causes are understood, projections of the influencing variables can be made and used in the forecast.

If past traffic data indicator is available for a number of years and the corresponding data on some socio economic indicator such as NSDP, PCI, Population, Industrial Production etc. is also available, then the data can yield an econometric model of the following type:

$$log_e P = A_o + A_1\ log_e NSDP \qquad \text{Eq 3.3}$$

Where P = Traffic Indicator Volume (may be classified like bus, car, truck etc.)

NSDP = Net State Domestic Product

A_o = Regression Constant

A_1 = Regression Coefficient

The value of A_1 is known as Elasticity coefficient. The elasticity coefficient is the factor by which the *NSDP* growth rate has to be multiplied to arrive at the growth rate of traffic.

(iii) Judgmental Method of Forecasting

Judgmental forecasting methods incorporate intuitive judgments, opinions and subjective probability estimates. Judgmental forecasting usually involves combining forecasts from more than one source and is of following types:

- Composite forecasts - combining forecasts from different methods
- Statistical surveys - to collect quantitative information from the items in a population (sampling)

- Delphi method - systematic, interactive forecasting method which relies on a panel of experts
- Scenario analysis - process of analyzing possible future events by considering alternative possible outcomes (scenarios)

To select a judgmental method, determine whether there are large changes, frequent forecasts, conflicts among decision makers, and policy considerations.

(iv) Reference Class Forecasting

Reference class forecasting predicts the outcome of a planned action based on actual outcomes in a reference class of similar actions to that being forecast. Reference class forecasting for a specific project involves the following three steps:

- Identify a reference class of past, similar projects.
- Establish a probability distribution for the selected reference class for the parameter that is being forecast.
- Compare the specific project with the reference class distribution, in order to establish the most likely outcome for the specific project.

Sometimes this process is a risky affair based on going with market popularity: what others do, sounds appealing but is unlikely to be of value because popularity and success may not be related and because it overlooks some methods.

(v) Recommended Forecasting Technique

Though there is no single forecasting technique applicable always for the similar kind of transport infrastructure facility, as mentioned in the earlier selections, the right kind forecasting technique depends on the project objectives, data and resources availability. Traffic forecasting is usually done by applying econometric method due the longer gestation period for the transport related projects due to high capital investments. Econometric method is particularly suited to the transport field due to the study of the underlying assumptions leading to the transport demand under consideration.

Based on the current market scenario (importance to PPP projects), it is also recommended to apply Judgmental and Reference class methods in addition to the quantitative forecasting methods like econometric and time series methods. And discretion is needed while selecting the proper forecasting method during the critical stages like planning, bidding etc. is provided in **Table 3.6**.

Table 3.6 Forecast Techniques

Parameter / Traffic Forecasting method	Quantitative Data	Knowledge on relationship variables	Expert Opinion	Info on similar category projects
Time series				
Causal/Econometric				
Traffic modeling				
Judgmental				
Reference class				

Very High *High* *Medium to High* *Low to Medium* *Low*

4. PLANNING AND DESIGN OF BUS PORT INFRASTRUCTURE

Planning and design of bus port infrastructure includes both passenger related facilities as well as bus operational facilities. Passenger facilities inside bus port include seating, kiosks, vending machines and parking. The bus port operational facilities include bus bays, bus lanes, entry-exits and circulation pattern. The components for bus port operational facility are detailed as below.

4.1 Bus Bay

A bus bay is a designated parking location where a bus waits for passengers to board and alight. The calculation of number of bus bays depends on factors like dwell time, clearance time, loading area capacity, per capita trip rate and base year and horizon year population. The factors affecting the calculation of number of bays are explained in subsequent sections.

4.2 Dwell Time

Dwell time of a bus refers to the time spent by bus at the scheduled stop/bay. Typically, this time is spent for entering/exiting bus bay (clearance time), boarding and alighting of passengers. The universal method for estimating the dwell time at ports is through the field survey by estimating actual entry clearance time, passenger alighting time, passenger boarding time, and exit clearance time. A summation of all above times is the actual field estimated dwell time as shown in Equation 4.1:

$$DT = T_a + T_b + t_{ec} + t_{exc} \qquad Eq\ 4.1$$

Where, DT is the dwell time, T_a is the passenger alighting time, T_b is the passenger boarding time, t_{ec} is entry clearance time, t_{exc} is exit clearance time.

The dwell time is dependent on many factors such as the passenger behavior and operational practices. Based on the bus function typology and number of doors, equations given in **Table 4.1** can be used to calculate the dwell times:

Table 4.1 Dwell Time for Single and Multi-Door Bus Entry

Single Door	3 stair (standard)	DT (min) = (4.14*P_b+3.04*P_a+30+10% delay)/60
	1 stair (low floor)	DT (min) = (1.81*P_b+1.56*P_a+t_{oc}+30+10% delay)/60
Multi Door	3 stair (standard)	DT (min) = (4.90*(P_{b1}+P_{a1})+30+10% delay)/60
	1 stair (low floor)	DT (min)) = (1.96*(P_{b1}+ P_{a1})+t_{oc}+30+10% delay)/60

Where,

P_b = *No of passengers boarding*

P_a = *No of passengers alighting*

t_{oc} = *Door opening & closing time (average time is 3 seconds)*

P_{b1} = *No of passengers boarding from the busiest door*

P_{a1} = *No of passengers alighting from the busiest door*

30 = seconds representing combined clearance time at entry and exit

delay = 10% additional time

The universal method is advisable for estimating dwell time for two categories:

(i) Through Buses: which means buses have neither origin nor destination in the bus port and these buses use bus port for intermediate passenger pickup.

(ii) Destined Buses: which are either originated or destined at bus port. These buses will have more dwell time as compared to through buses.

In absence of data the dwell time could be taken as 10 min. However, considering this value of dwell time may not lead to an efficient bay allocation and that actual data collection is suggested. Also, passenger boarding and alighting rates are function of variables such as bus floor height relative to platform height and level of crowding already on the bus etc. and these can be measured through actual observation.

4.3 Passenger Loading Capacity at Bay

Capacity can be defined in terms of the number of passengers per hour that can be loaded, or the frequency of buses that can depart from the berth. It is reached at the time when a bay is completely occupied by loading buses or is reserved for the expected arrival of buses. Many factors influence the capacity of a berth. The best known and most documented factors are the average dwell time, clearance time and early arrival and late arrival time difference to scheduled arrival. The peak passenger loading capacity of a bay at bus port can be calculated using the following formula:

$$Capacity\left(\frac{bus}{h}\right) = \frac{Seconds\ in\ an\ hour\ available\ for\ bus\ movement}{Seconds\ that\ a\ bus\ occupies\ the\ bus\ bay} \qquad Eq\ 4.2$$

The Equation 4.2 can written as:

$$C_b = \frac{3600}{P_a t_a + P_b t_b + t_c + t_{oc} + E_a + L_a} \qquad Eq\ 4.3$$

Where, C_b is Capacity of bus bay expressed in bus/h during peak loading condition, t_c is the clearance time, P_b and P_a are the number of passengers boarding per departure and alighting per arrival, t_a and t_b are the per person alighting and boarding times, E_a is the difference between early arrival time and schedules arrival time. Similarly L_a is the difference between late arrival time and schedules arrival time. If the capacity is needed in terms of peak passenger loading capacity (pax/h), the Equation 4.3 should be multiplied by P_b. The clearance time t_c is the non-loading time between the closing of the passenger doors of a departing bus and the opening of the passenger doors of the next arriving bus. In the absence of data, the clearance time can be as low as 10 seconds and the default values of t_a and t_b can be selected from the **Table 4.2** (TCQSM 2013).

Table 4.2 Default Values of per person Alighting and Boarding Times

	Average Passenger Service Time (s/p)	
Situation	**Range**	**Suggested Default**
BOARDING		
Off board fare collection	1.75-2.5	1.75
ALIGHTING		
Front door	1.4-3.6	2.5
Rear door	1.2-2.2	1.75

Note: *Add 0.5 sec/passenger to boarding times when standees are present. Add 0.5 sec/passenger for non-level boarding.*

4.3.1 *Estimation of Bus Bays*

Sample Bus bays calculation is provided in the below tables by considering the various bus port parameters like ideal dwell time, PCTR, existing population and horizon year population of a city. Also, it is assumed that existing bus port is available in the city under consideration with assumed holding capacity in terms of number of bays. The suggested average PCTR value range to be used in bus bay estimation is 0.03-0.06. The bus bay calculation is divided into three parts viz., total number of bus bays required, total number of boarding bays and total number of alighting bays. For planning consideration bus bay allocation may happen in two ways i.e., common bay allocation and segregated bay allocation. In the common bay allocation, the boarding, idling and alighting operations takes place at the same bay, this is preferred if the average layover time is less than or equal to 15 mins. Whereas, in the segregated bay allocation, the boarding, idling and alighting takes place at different bays. The calculation of the segregated bays is presented in two scenarios i.e., when the primary survey data is available and when the primary survey

data is unavailable. The alighting bay calculation under both the scenarios will remain same. The boarding bays calculated under the segregated bay estimates will suffice in the case of the common bays estimation.

4.4 In case Primary Survey Data is unavailable

Assumptions/Input Values for Estimation of Bus Bays in Bus Port is given in **Table 4.3**.

Table 4.3 Estimation of Number of Bus Bays - Input Values (where Primary Data is unavailable)

S.No.	Assumptions/Input values	Remarks
1	City : 'A'	City name
2	Existing Population : 20.0 Lakhs	Population of the city in base year
3	Projected Population : 30.0 Lakhs	Population of the city in the horizon year
4	PCTR: 0.05	Per capita trip rate (intercity/regional bus traffic)
5	Existing number of boarding bus bays	20 (One bus port with twenty boarding bays)
6	Average dwell time (min): 10:00	Average dwell time which is considered to be the ideal dwell time
7	Operational hours of the bus port: 16 hrs in a day	Number of operational hours in a day
8	Bus Occupancy: 35 nos'	Average bus occupancy
9	Peak hour demand (%) : 8%	Share of peak hour demand
10	Share of buses spent in idle parking : 10%	% of buses needed the idle parking bays (also observed from data analysis)
11	Turnover rate of idle parking bay : 4.0	Average idling time of the bus in idle bay: 4.0 hours [16 operational hours / 4.0 hr halt time]
12	Share of passenger alighting : 40%	40%: Alighting and 60%: Boarding [Bus occupancy]

4.5 Estimation of Boarding Bays

Estimation of number of Boarding Bays is given in **Table 4.4**.

Table 4.4 Estimation of Number of Boarding Bays (where Primary Data is unavailable)

S.No.	Calculation	Output
1	Passenger footfall = (30,00,000 X 0.05)	150,000
2	Peak hour demand (footfall) = 8% X daily demand	12,000
3	Number of buses operating in peak hour = [Peak hour demand/bus occupancy]	343 (rounded)
4	Service rate of the boarding bay per hour = 60 mins/dwell time	6 buses per boarding bay
5	Number of bays required = Peak hour buses/Bus bay service rate	57.2 (rounded to 60)
6	Additional bus bay requirement = Required bus bays in horizon year – Existing number of bays	40 [60 – 20]

4.6 Estimation of Alighting Bays

Estimation of number of Alighting Bays is given in **Table 4.5**.

Table 4.5 Estimation of Number of Alighting Bays (where Primary Data is unavailable)

S.No.	Calculation	Output
1	Number of boarding bays	40
2	Number of buses in peak hour = [boarding bays X 60 mins]/Dwell time	240 [(40 X 60)/10]
3	Time to clear the passengers in alighting bay [share of passengers in alighting bay:40%]	01:15 (min:sec)
4	Bus service rate of alighting bay per hour = 60 mins/Alighting clearance time	48 buses per hour
5	Number of Alighting bays required = [Peak hour buses/Bus service rate in alighting bay]	5 (rounded value of 240/48)

4.7 Estimation of Idle Parking Bays

Estimation of number of Idle Parking Bays is given in **Table 4.6**.

Table 4.6 Estimation of Number of Idle Parking Bays (where Primary Data is unavailable)

S.No.	Calculation	Output
1	Estimated number of buses trips in a day	3000 [75 buses/bay X 40 bays]
2	Daily number of buses in idle parking bays = [Daily buses X share of buses in idle parking]	300 [3000 X 10%]
3	Required number of idle parking bays = [number of buses in idle parking X Idle bay turnover rate/Operational hours of bus port]	75 [300 X 4.0/16]

4.8 In case Primary Survey Data is available

Assumptions/Input Values for estimation of bus bays in bus port is given in **Table 4.7**.

Table 4.7 Estimation of Number of Bus Bays - Input Values (where Primary Data is available)

S.No.	Assumptions/Input values	Remarks
1	City : 'A'	City name
2	Estimated number of Buses in a day	1000
3	Estimated Number of buses in peak hour in design period	200
4	Existing number of boarding bus bays	20 (One bus port with twenty boarding bays)
5	Average dwell time (min): 10:00	Average dwell time which is considered to be the ideal dwell time
6	Operational hours of the bus port: 16 hrs in a day	Number of operational hours in a day

7	Bus Occupancy: 35 nos'	Average bus occupancy
8	Peak hour demand (%) : 8%	Share of peak hour demand
9	Share of buses spent in idle parking :10%	% of buses needed the idle parking bays (also observed from data analysis)
10	Turnover rate of idle parking bay :4.0	Average idling time of the bus in idle bay : 4.0 hours
11	Share of passenger alighting: 40%	40%: Alighting and 60%: Boarding [Bus occupancy]

4.8.1 *Estimation of Boarding Bays*

Estimation of number of Boarding Bays is given in **Table 4.8**.

Table 4.8 Estimation of Number of Boarding Bays (where Primary Data is available)

S.No.	Calculation	Output
1	Number of buses in peak hour	200
2	Dwell time in minutes	10
3	Total Dwell Time Required in Minutes = [Number of buses in peak hour X Dwell time in minutes]	2,000
4	Number of bays required = [Total Dwell Time Required in Minutes/60]	33.3 (rounded to 30)
5	Additional bus bay requirement = Required bus bays in horizon year – Existing number of bays	10 [30 – 20]

4.9 Estimation of Idle Parking Bays

Estimation of number of Idle Parking Bays is given in **Table 4.9**.

Table 4.9 Estimation of Number of Idle Parking Bays (where Primary Data is available)

S.No.	Calculation	Output
1	Estimated number of buses trips in a day	1000
2	Daily number of buses in idle parking bays = [Daily buses X share of buses in idle parking]	100 [1000 X 10%]
3	Required number of idle parking bays = [number of buses in idle parking X Idle bay turnover rate/ Operational hours of bus port]	25 [100 X 4.0 / 16]

In addition to the above calculations, a few guiding numbers for estimating alighting bays are given in **Table 4.10.**

Table 4.10 Guidelines for Segregated Boarding & Alighting Bays

S.No.	Boarding Bays	Alighting Bays
1	10 bays	2 bays
2	20 bays	3 bays
3	40 bays	5 bays
4	60 bays	8 bays

4.9.1 *Loading Berth Design (Boarding and Alighting Bays)*

Dimensions for parallel and shallow saw tooth loading berths shall be designed considering a typical bus length (12 m), bus width (2.5 m) and a minimum turning radius of the outer body at crawl speed (about 13 m).

4.9.2 *Parallel Loading Berths*

The parallel loading berth offers flexibility for re-arrangement to accommodate a range of buses from mini-buses to articulated buses. Its main disadvantage is its inability to restrict buses to their own designated berths. Especially where short berths are used, drivers tend to encroach on the berth in front of them. This makes the entry of the next bus behind them more difficult and results in large tail-outs, which can encroach into the aisle and prevent the passage of buses.

For independent arrivals and departures, the length of a berth has to provide an adequate approach length for manoeuvring into the berth and parking parallel to the curb, the length of the bus and sufficient exit length in front of the bus to enable it to manoeuvre out avoiding a bus parked in front of it. There is a close relationship between the length of the berth and the width of aisle. The shorter the exit length available, the wider the aisle has to be to permit the bus to manoeuvre out of the berth. Using a variety of buses, tests were carried out to determine the relationship between various lengths of parallel berths and the width of aisle required. The preferred parallel berth should be based on a module (M) of 22 m in length and a 7.5 m width (W) of aisle. An 8 m width of aisle would be necessary if the module length was reduced to 20 m. However, at that short length, the shallow sawtooth berth should be seriously considered. At an 18 m length of module, the aisle width should be at least 8.75 m and a shallow sawtooth design would be preferred. Reducing the module to a length of 17 m would make independent arrivals and departures unfeasible. The below **Table 4.11** and **Fig. 4.1** gives details of various combinations of module length and aisle width for the design bus.

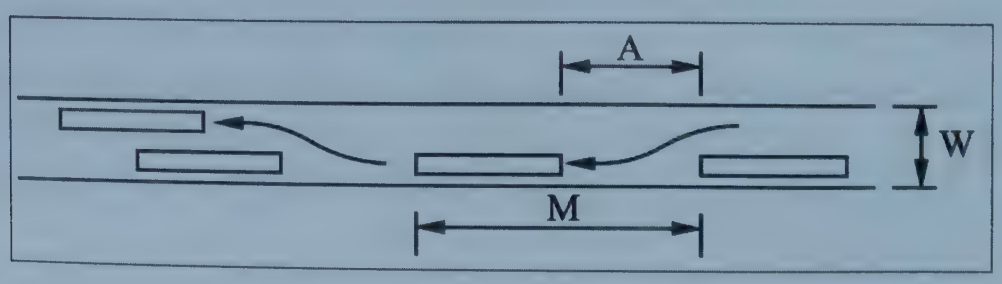


Fig. 4.1 Parallel Loading Berths

Table 4.11 Guideline Dimensions for Parallel Loading Berths

M	A	Minimum	Desirable	Comments
26	14	6.75	7.25	Max. for Single
25	13	7.0	7.5	
24	12	7.0	7.5	
23	11	7.25	7.5	
22	10	7.25	7.5	Preferred
21	9	7.5	7.75	
20	8	7.5	8.0	Consider Sawtooth
19	7	8.0	8.5	Consider Sawtooth
18	6	8.25	8.75	Prefer Sawtooth
17	-	-	-	Breakdown of Independent arrival and departures

4.9.3 *Shallow Sawtooth Loading Berths*

The main advantage of the sawtooth is the ease of manoeuvring into it. It has a saving of about 2 m in length over a parallel berth providing the same level of service. The preferred design has a 20 m length of module (M) associated with a 2.0 m depth (D) of sawtooth and a 7.5 m width (W) of aisle outside of the sawtooth. An important feature of a sawtooth berth is that drivers are prevented from encroaching on the berth in front of them.

The below **Table 4.12** and **Fig. 4.2** give a range of dimensions for sawtooth berths. A novel feature is the development of a very shallow sawtooth berth, in which the sawtooth indent is reduced to 1.00 or 1.25 m. Saving a little on the width of the module often allows an extra row of berths to be provided on a restricted site. The very shallow sawtooth improves the bus pull-out manoeuvre in terms of avoiding the whip-lash of the rear overhang.

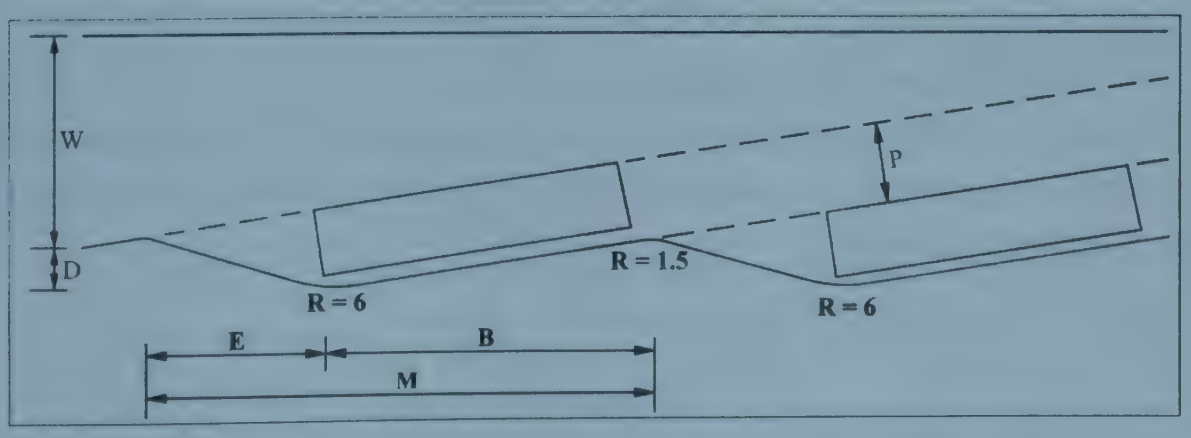


Fig. 4.2 Shallow Sawtooth Loading Berth Design

Table 4.12 Guideline Dimensions for Shallow Sawtooth Loading Berths (all values in m)

M	E	B	D	P	W		W+D		Comments
					Min.	Des.	Min.	Des.	
20	7	13	1.00	1.53	7.25	7.50	8.25	8.50	
20	7	13	1.25	1.91	7.25	7.50	8.50	8.75	
20	7	13	1.50	2.29	7.25	7.50	8.75	9.00	
20	7	13	1.75	2.67	7.25	7.50	9.00	9.25	
20	7	13	2.00	3.04	7.25	7.50	9.25	9.50	Preferred Overall
19	6	13	1.00	1.46	7.25	7.50	8.25	8.50	
19	6	13	1.25	1.81	7.25	7.50	8.50	8.75	
19	6	13	1.50	2.18	7.25	7.50	8.75	9.00	Preferred for M=19
19	6	13	1.75	2.53	7.25	7.50	9.00	9.25	
19	6	13	2.00	2.89	7.25	7.50	9.25	9.50	
18	6	12	1.00	1.38	7.50	7.75	8.50	8.75	
18	6	12	1.25	1.72	7.50	7.75	8.75	9.00	
18	6	12	1.50	2.06	7.50	7.75	9.00	9.25	Preferred for M=18
18	6	12	1.75	2.40	7.50	7.75	9.25	9.50	
18	6	12	2.00	2.74	7.50	7.75	9.50	9.75	

The designer is usually faced with the problem of heaving to accommodate a desired of loading berths in a restricted and often inadequate site. The **Table 4.13** provides the designer with information on the type of berth and operating conditions that would be achieved by a variety of berth lengths from 13 m to 35 m.

Table 4.13 Bus Loading Berths for various Modules of Length

Length of Module (m)	Width of Aisle including Depth of Sawtooth where applicable (m)	Option for use of Berth	Operating Conditions and Preference
13	7.5	Queue buses nose to tail	Non-independent arrival and departure
	7.5	Queue buses nose to tail	Non-independent arrival and departure but allows other buses to pass
18	8.25 - 8.75	Parallel berths independent arrival and departure.	Delays result when frequencies are high Buses encroach on other berths
	9.0 - 9.25	Sawtooth preferred	Avoids encroachment
19	8.0 - 8.5	Parallel	Delays result when frequencies are high Buses encroach on other berths
	8.75 - 9.00	Sawtooth	Smooth operation
20	7.5 - 8.0	Parallel	Satisfactory operation - sawtooth preferred
	9.25 - 9.5	Sawtooth	Preferred module for sawtooth
21	7.5 - 7.75	Parallel	Reasonable operating conditions
22	7.25 - 7.5	Parallel	Preferred module for parallel - good operating conditions
23	7.25 - 7.5	Parallel	Tail-out reduces
24	7.0 - 7.5	Parallel	Little tail-out
25	3.5	Queue 2 buses - non - Independent arrival and departure - Parallel berths	Can share berth with another route of suitable frequency
26	6-75 - 7.75	Maximum layout for single parallel berths	Good - Independent arrivals and departures
26	3.5	Queue 2 Buses Non - Independent arrival	Inflexible Needs holding area
32	9.75	Double sawtooth - First bus loading second bus waiting. Can accommodate articulated bus.	Good - High frequency
33	7.5 - 8.0	Double parallel berth - First bus loading second bus waiting. Can accommodate articulated bus.	Reasonable - High frequency feasible for double bus berth
35	7.25 - 7.5	- ditto - maximum for double parallel	

4.10 Entry/Exit Points and Circulations (Vehicles only)

The successful functioning of a bus port site depends on good access for vehicles and pedestrians to the connecting roadway network.

Some general principles that should be kept in mind while planning and designing access in and around a bus port are:

- Access roads should be kept to a minimum width of 7 m, providing the most direct access to a site facility. Where access roads have a combined use, with bus and automobile traffic mixed, entrance and exit conditions from each facility should be carefully studied to minimize turning movement conflicts.
- In addition to bus access, access for station facility, maintenance, police, and emergency vehicles should also be considered.
- Connections should be designed to prevent encroachment of bus turning movements into opposing traffic lanes. Traffic volumes, existing signalization, available rights-of-way, street widths, and other design elements should be evaluated when considering channelization to eliminate encroachments of bus turning movements into traffic lanes moving in the same direction.
- Minimize the number of access points with adequate spacing. A sufficient number of entrances should be provided so that traffic circulates at adequate levels of service.
- Right-turn storage pockets are recommended at entry and exit location, so that buses have adequate turning radii width and reduced conflicts with through traffic flows.
- At locations near highways, locating exits directly across from highway exit ramps should be avoided to discourage wrong-way entry onto the highway
- Entrances and exits to bus facilities should be of adequate lane widths and stacking distances to allow maneuvering of buses. (Source: WMATA Station Site and Access Planning Manual)
- Minimum sight distance shall be provided throughout the entry/exit, access roads and bus circulation area, as per IRC:86 “Geometric Design Standards for Urban Roads and Streets” to ensure that bus drivers and other users have a clear unobstructed view.
- The decision on number of entry and exit for the bus port and circulation pattern (one-way or two-way movement) shall be provided based on the assessment of road capacities in the influence area, size of the bus port plot, based on queue length observed during analysis and number of buses entering/exiting the bus port in peak hour. The data of TVC, Bus Count & Pick-up/Drop-off will help us access the feasible circulation plan.

4.11 Parking and Pickup Drop off Facilities

Parking needs shall be assessed for all modes by considering demand of these dispersal modes, proposed development of bus port infrastructure through detailed study as part of the bus port project and shall also take into account the city/town policy on parking provisions. Parking demand could be assessed based on the existing bus port passenger forecast, availability connectivity options, travel pattern of the users, share of access modes using the bus port. Existing parking demand shall be assessed through parking surveys at the bus port by collecting data on access modal share, parking accumulation and duration etc. This parking demand is forecasted in future years for assessing the total provisioning of parking in bus port design.

4.11.1 *Pickup/Drop-off Facilities*

Bus Port also require spaces for drop-off/pick-up. The drop-off/pick-up needs can be determined on the basis of drop-off/pick-up survey conducted in bus port areas for existing bus ports. Based on demand for such facilities, it is recommended that separate pickup/drop-off bays are to be provided so that they do not cause hindrance to normal traffic flow. The location should be integrated to the bus port building/waiting area, typically close to the pedestrian entrance to the building. The size of the drop-off area will depend upon the expected number of vehicles including private car, taxis and IPT dropping or picking up passengers at the bus port which are calculated based on surveys and then forecasted for horizon year. In absence of any such information, some guidelines are produced in this document which could be used by cities.

4.11.2 *Other Feeder Mode Infrastructure*

Feeder transport in Indian cities are largely covered by Intermediate Public Transport (IPT) modes like auto- and cycle- rickshaws. With the arrival of taxi aggregators in large and mid-sized cities, taxis have also assumed importance. All of these modes should be considered in order to provide access to the largest segment of population.

The proportion of feeder system need in the bus port shall be determined from the origin-destination & boarding/alighting surveys. Based on the O-D surveys the access/dispersal mode of users shall be analyzed and forecasted based on passenger growth. This will help in determining the facilities/infrastructure to be allocated for these modes. Subsequently, feeder infrastructure for various modes such as IPT stands, mini bus and bus stops shall be estimated and integrated with the bus port design.

4.12 Provisions for Pickup/Drop off and Parking

Parking spaces are based on proposed bus port development, adjacent land use and the city policy on parking. Since the land at the bus port is premium in general due to the scarcity of land availability the overall parking needs shall satisfy both the users and long term parking strategies for the city. Long-term private parking is typically avoided at bus ports by using pricing instrument.

In case no comprehensive study was undertaken for the bus port, the **Fig. 4.3** mentions the recommended access modal share at the bus ports for two cases: 1) without good public transport/metro service in vicinity and 2) with metro/good public transport service in vicinity.

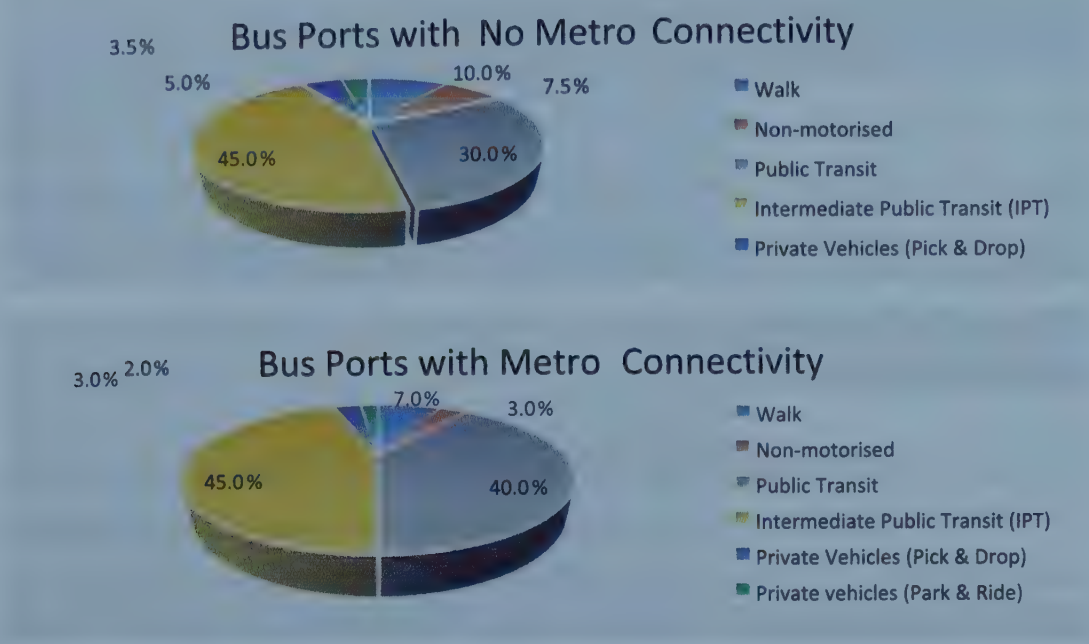


Fig. 4.3 Proposed Access Modes at the Bus Ports for Planning

Similarly, recommended space provisions at bus port for various other modes are also provided in the **Fig. 4.4** below.

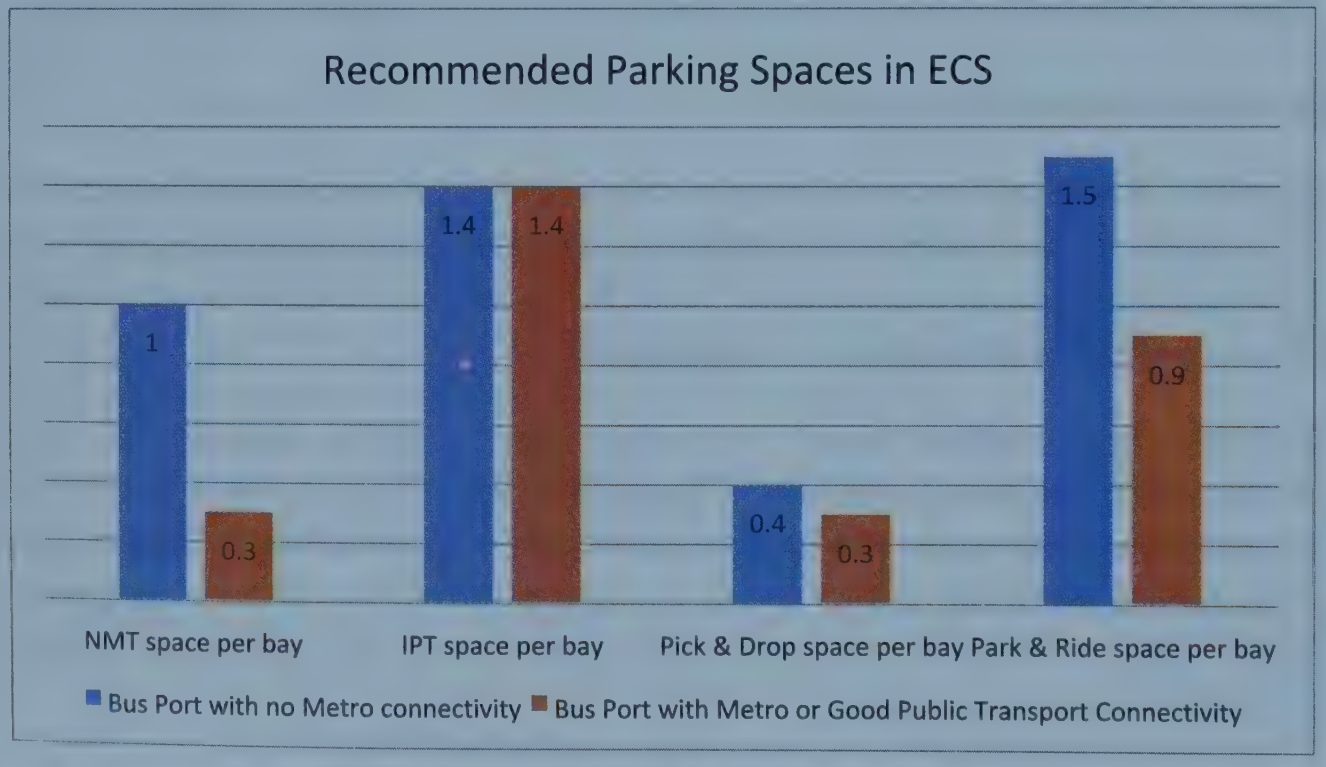


Fig. 4.4 Recommended Parking Spaces for Various Modes at the Bus Ports

4.13 Bus Movement, Geometrics and Design

The bus movement and related geometrics depends on the general type of buses available in India. Based on the type of bus, the turning radii, lane width and other geometric design parameters are decided.

4.13.1 *Bus Types*

Bus width is generally considered as distance between the left side rear view mirror to right side rear view mirror. Bus length is considered as bumper to bumper distance, while the height of the bus is measured from ground level to the very top (including air conditioning unit if any on the roof). It is important to note that it is preferable to plan for the larger bus rather than the smaller bus types because it will ensure the smooth operation of a smaller bus type as well as be more flexible in the future. The following are the major bus types:

1. Low Floor Bus 2. High Floor Bus 3. Articulated Bus 4. Double Decker Bus
5. Sleeper Bus 6. Multi Axle Bus 7. Battery Electric Bus 8. Mini Bus

The different types of buses that are typically operating in India are shown in **Annexure**: **Types of Buses**. The **Annexure** gives details of the bus dimensions.

4.13.2 *Turning Radii*

Turning radii for the different bus types are shown in the **Table 4.14** below. These minimum turning radii should be used while designing the curbs at intersections of access roads or any road that incorporates movement of the bus. Curb radii that are less than minimum turning radius will result in problematic bus movement that will cause damage to the curb and danger to the pedestrians. It is a good practice to design the bus turning envelope with an offset of 300 mm from the curb so as to ensure that the curb is always protected.

Table 4.14 Design Dimensions from Maximum Values of Buses in use in India

S.No		For Bus Port	Wheel base	Length	Width	Height	Ground Clearance	Turning Diameter	Front Overhang	Rear Overhang
1	Low Floor	✓	6300	12000	2600	3350	280	20200	2490	3150
2	High Floor	✓	6095	11995	2500	3260	250	17890	2550	3350
3	Articulated	×	-	-	-	-	120	-	-	-
4	Double Decker	×	5100	7725	2500	4000	232	-	700	2300
5	Sleeper	✓	6300	12000	2550	3770	275	23000	2340	3360
6	Airport	✓	7174	13700	2600	3700	270	21000	2850	2840
7	Multi-Axle	✓	7400	14500	2600	3700	270	22200	2850	2840
8	Electric	✓	6300	12000	2600	3350	280	20200	2490	3150
9	Minibus	×	3100	5550	2200	2800	210	12000	900	1550

– All dimensions are in mm

– Dimensions of articulated buses vary as per the Modifications, as these are not manufactured in India anymore.

Maximum values to be considered.

4.14 Decelerating Lane

It is recommended that the bus entering the bus port decelerates in the major thoroughfare itself in a 'decelerating lane' rather than within the access road so as to avoid danger to slower moving traffic and people within the bus port site. Same care should be taken for exiting buses in terms of an accelerating lane. The **Fig. 4.5** explains how a decelerating lane will work for a bus that has to turn left to enter a bus port site. It is recommended that the width of these speed change lanes should be slightly wider than the width of the bus lanes recommended within the site which is 3.5 m. **Table 4.15** shows the standard dimension for bus accelerating and decelerating lanes.

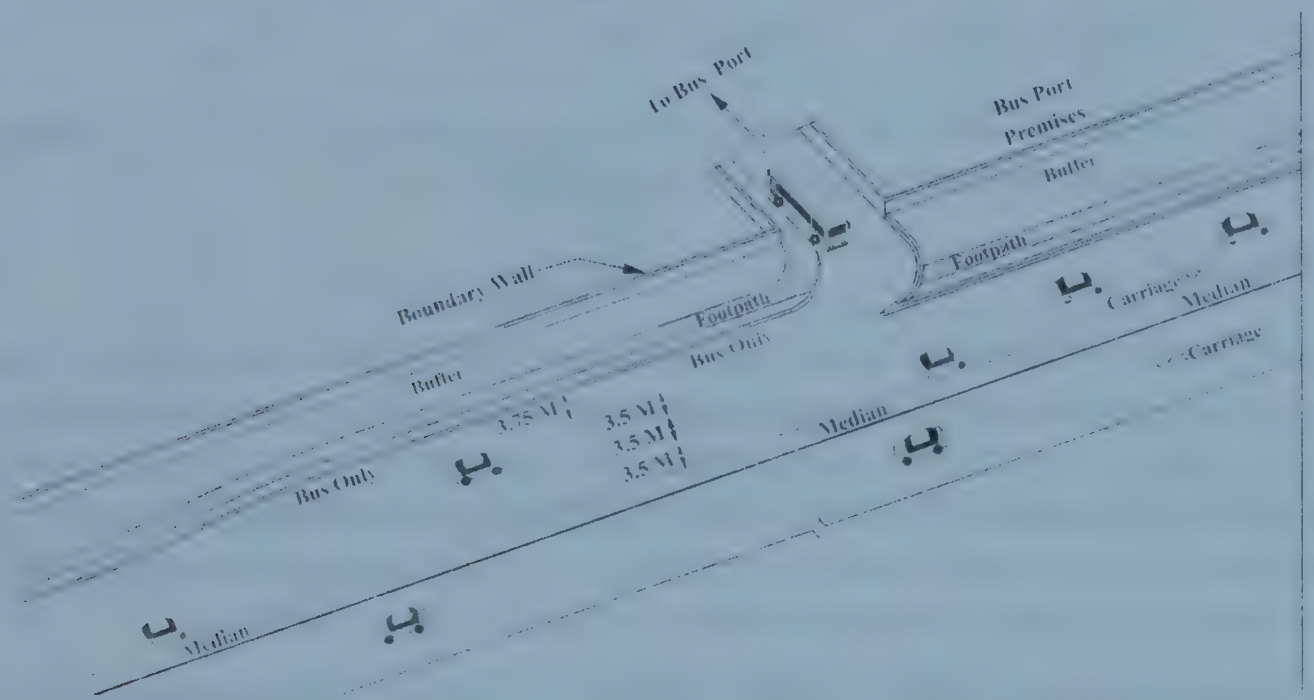


Fig. 4.5 Decelerating Lanes for Buses

Table 4.15 Standard Dimension for Bus Accelerating and Decelerating Lanes

Design Speed of Approach Road (kmph)	Length of Taper (a),(m)	Total length of deceleration lane, including taper (a+b), (m) Max min								Total length of acceleration lane, including taper (a+b),(m) Max min.							
65	60	100	90	85	75	60	-	-	-	100	75	70	-	-	-	-	-
80	70	130	120	115	110	100	90	-	-	210	190	180	150	120	-	-	-
100	80	150	150	145	140	130	120	100	90	340	320	300	270	240	180	120	-
110	90	165	165	160	150	145	140	115	100	465	450	420	400	370	300	250	175

4.15 Lane Width

It is recommended to use 3.5-meter lane widths for buses on access roads from the major thoroughfare as well as in the bus port. However as mentioned before deceleration lanes are recommended to be wider i.e. 3.75 meters.

4.16 Gradient

The **Fig. 4.6** show the recommended slopes for ramps in terms of breakover angle, approach angle and departure angle. In general, the maximum slope a large 12-meter bus can negotiate safely is a 6 to 12% slope (Riverside Transit Agency, 2004). Care should be taken to ensure that boarding and alighting takes place only on level surfaces. It is generally recommended that the access and departure/exit roads should maintain a gradient in order to prevent draining of water from the thoroughfare into the bus port site.

It is to be noted that in the figures below, the breakover angle and departure angle is calculated for low floor buses because of its particular geometry while approach angle is critical for multi axle buses because of its long overhang over the front wheel.

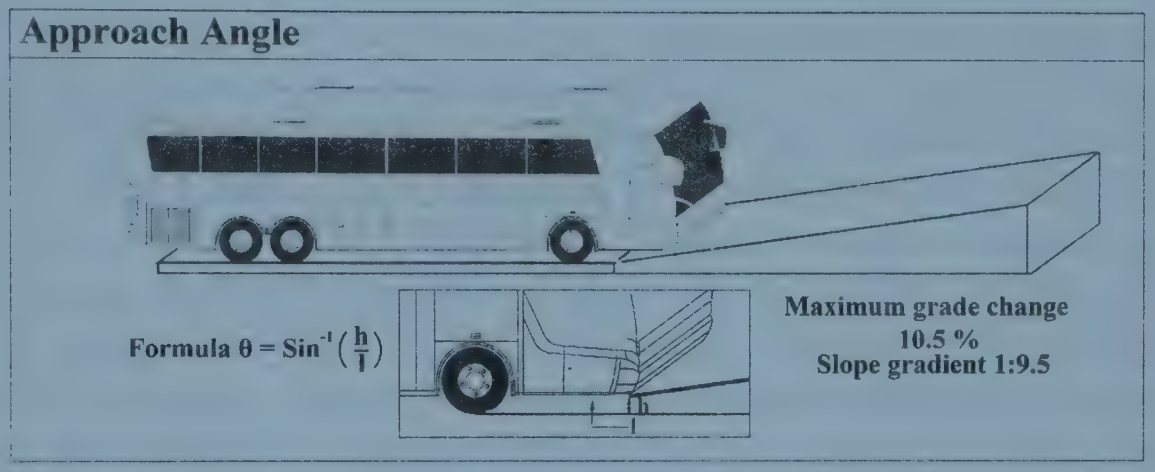


Fig. 4.6 Standard Dimensions for Vertical Geometry

4.16.1 *Intersections*

The design of intersections is critical in ensuring safe and easy bus maneuverability especially where the bus port access road meets with the thoroughfare. Care should be taken to establish no parking zones at the corners of intersections and minimum distances if there are bus stopping areas near the intersections. Pedestrian and non-motorized transport safety is also paramount since conflict with these modes of movement is most likely to happen.

4.16.2 *Horizontal and Vertical Clearances*

The access road to the bus port as well as the bus lane or leftmost lane of the major thoroughfare from which it connects are the subject of this section. It is assumed that the bus will travel slowest on the left most lane of the major thoroughfare before it turns into the bus port access road. It must be ensured that these movement areas are free of any overhead disturbances like low hanging electric lines, tree branches, or roof extensions. As a thumb rule, there should be an overhead clearance of at least 5.5 m from ground level to ensure that the bus can safely move through. The bus doors should open with no obstruction at locations such as street side curb, where the bus is intended to stop and alight passengers. On all roads with or without kerb and with or without shoulder, the extreme edge of the ground mounted sign, street furniture adjacent to the roadway shall be at a distance of 600 mm to 3 m from the carriageway or paved shoulder edge depending upon the local conditions. For roads with kerbs, it shall not be less than 300 mm away from kerb line, but in no case shall any part of the sign come in the way of vehicular traffic. The bus doors should open with no obstruction at locations such as street side curb, where the bus is intended to stop and alight passengers.

4.16.3 *Bus Bay Geometrics*

The **Fig. 4.7** to **Fig. 4.17** represent different kinds of bus bay systems and minimum dimensions associated with each. Although the appropriateness of a design is dependent on the specific site and space constraints, following process can be followed to choose the right bay system.

(i) Establish the number of alighting only bays, loading and alighting bays and idling bays required.

(ii) Choose the appropriate bus bay type for each category **(Table 4.16)**.

Table 4.16 Geometries of Bus Bays

Type of Bay	Usage	Preferred Geometries
Alighting Bays	Alighting bays refers to situations where the bus stops primarily to let passengers alight.	The most preferred bus bay geometries are the parallel and shallow saw tooth systems. This is because there is no or minimal need to reverse the bus in both geometries and therefore manoeuvring in and out of the bus bay space is quick and easy.

Loading Bays	Loading bays primarily refers to situations where it is expected that the bus will stop for a longer duration to enable passengers to board, so that it can start its trip immediately after boarding is complete.	The preferred geometries for this type are the forty-five or sixty degree saw tooth configurations.
Idling Bays	Idling bays are for buses which after complete alighting are in long term waiting before beginning to board at the appropriate boarding bay.	The preferred geometries for this type is 90-degree bay geometries so as to provide maximum number of bays and to possibly double up as a repair area/workshop.

The configuration of bus bays depends on the shape of the plot and future capacities. Four types of bus loading configurations are typically used (**Table 4.17**):

Table 4.17 Types of Bus Loading Configurations Alighting Bays

S.No.	Type of Bus Bay	Description
1	Linear (curb-side)	These bays can operate in series and have capacity characteristics similar to on-street bus stops.
2	Saw-tooth	This loading configuration is popular in usage in urban transit centres and alighting bays where quick servicing of passengers is needed
3	Angular	This loading type is limited to one bus per bay, and requires buses to back out. This is often used for inter-city bus ports, with relatively long dwell times (> 5 min), single-door entry, and luggage loading requirements.
4	Drive Through	Drive-through angle bays do not require buses to back out of the bay and may accommodate multiple vehicles. However, these bays pose conflict of passenger and bus movement.

The sample dimensions for the various bus bay systems described above are given in the **Fig. 4.7 to Fig. 4.17.**

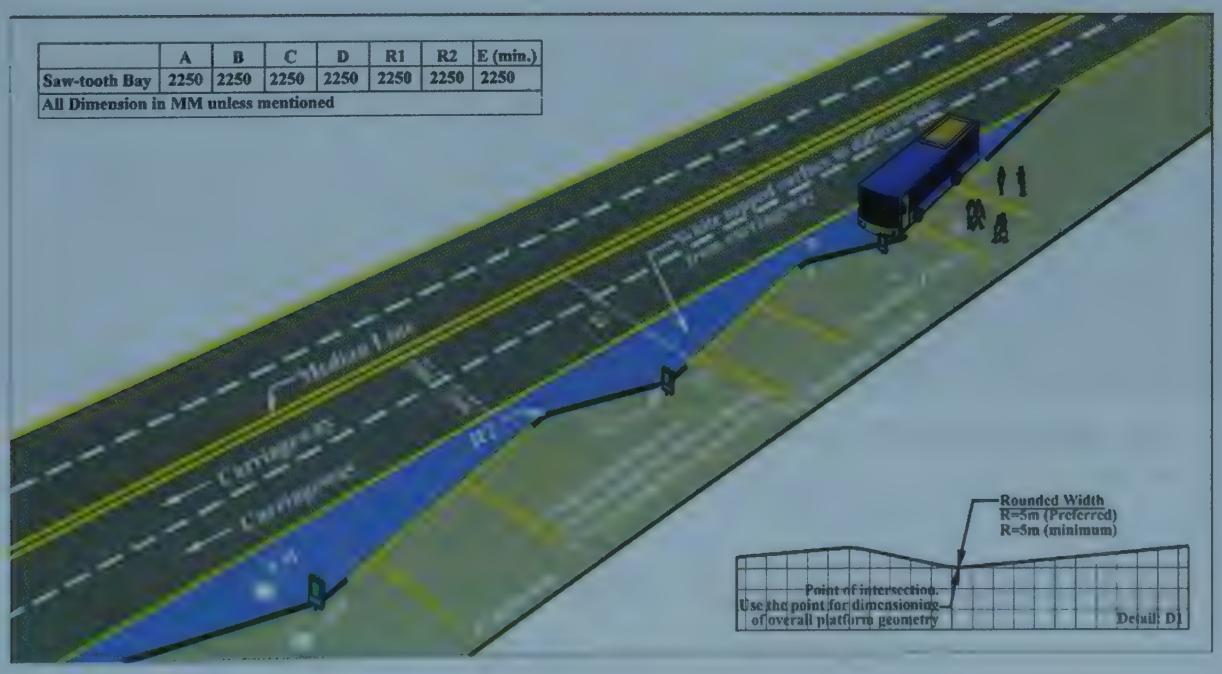


Fig. 4.7 Standard Dimensions for Shallow Saw-Tooth Bays

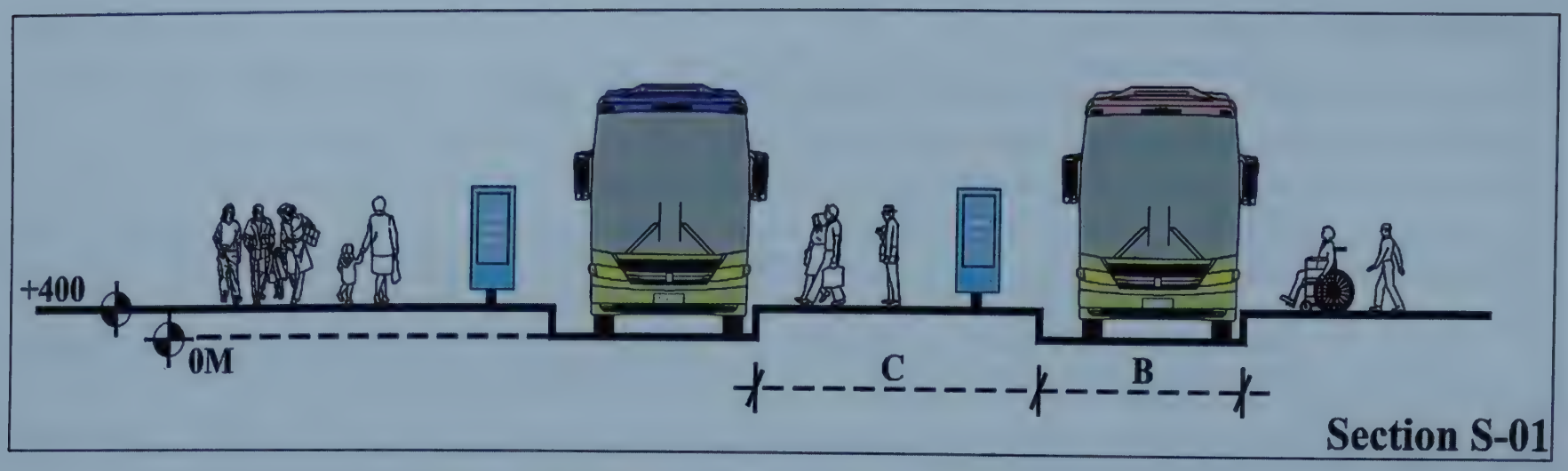
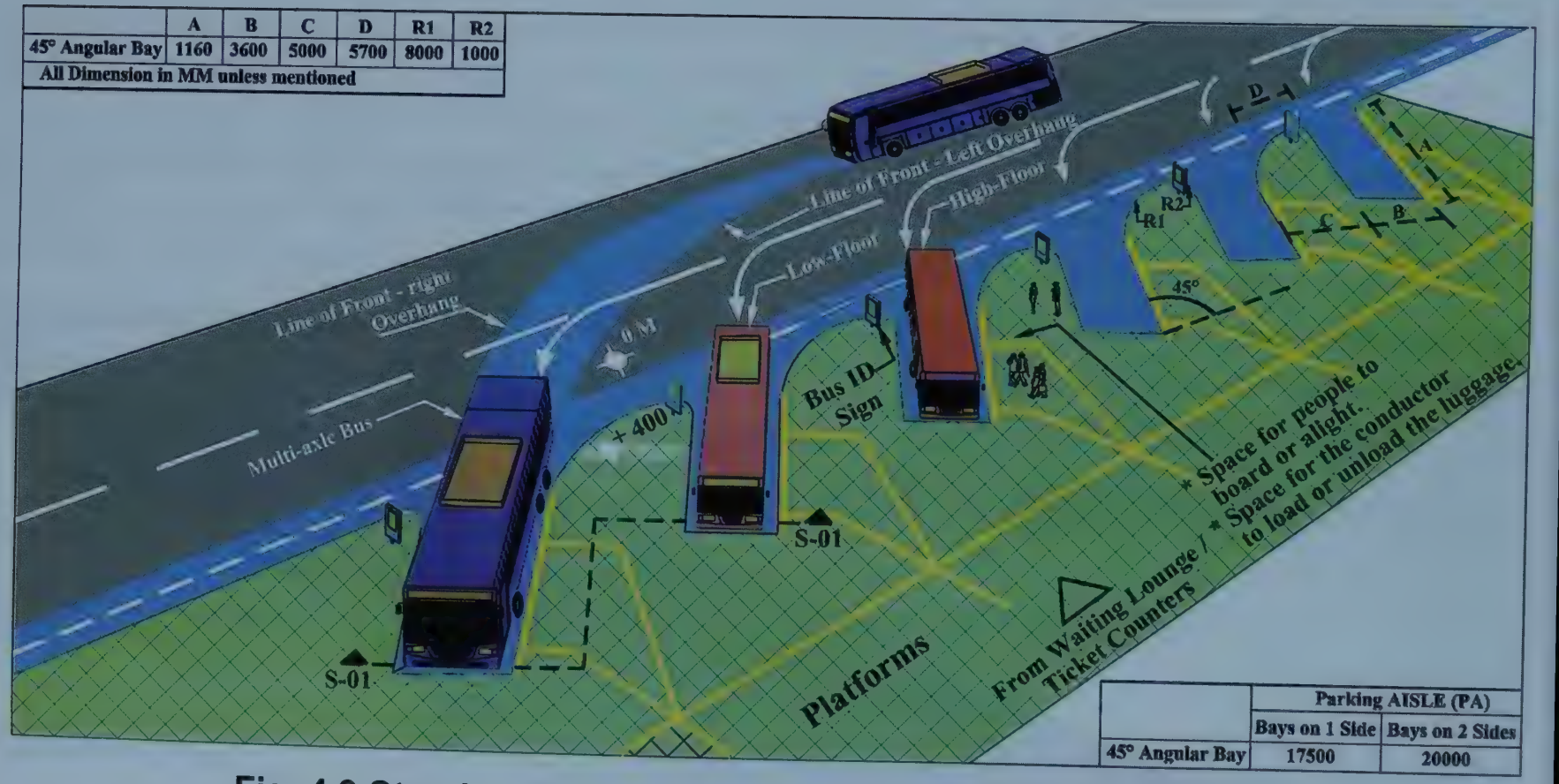


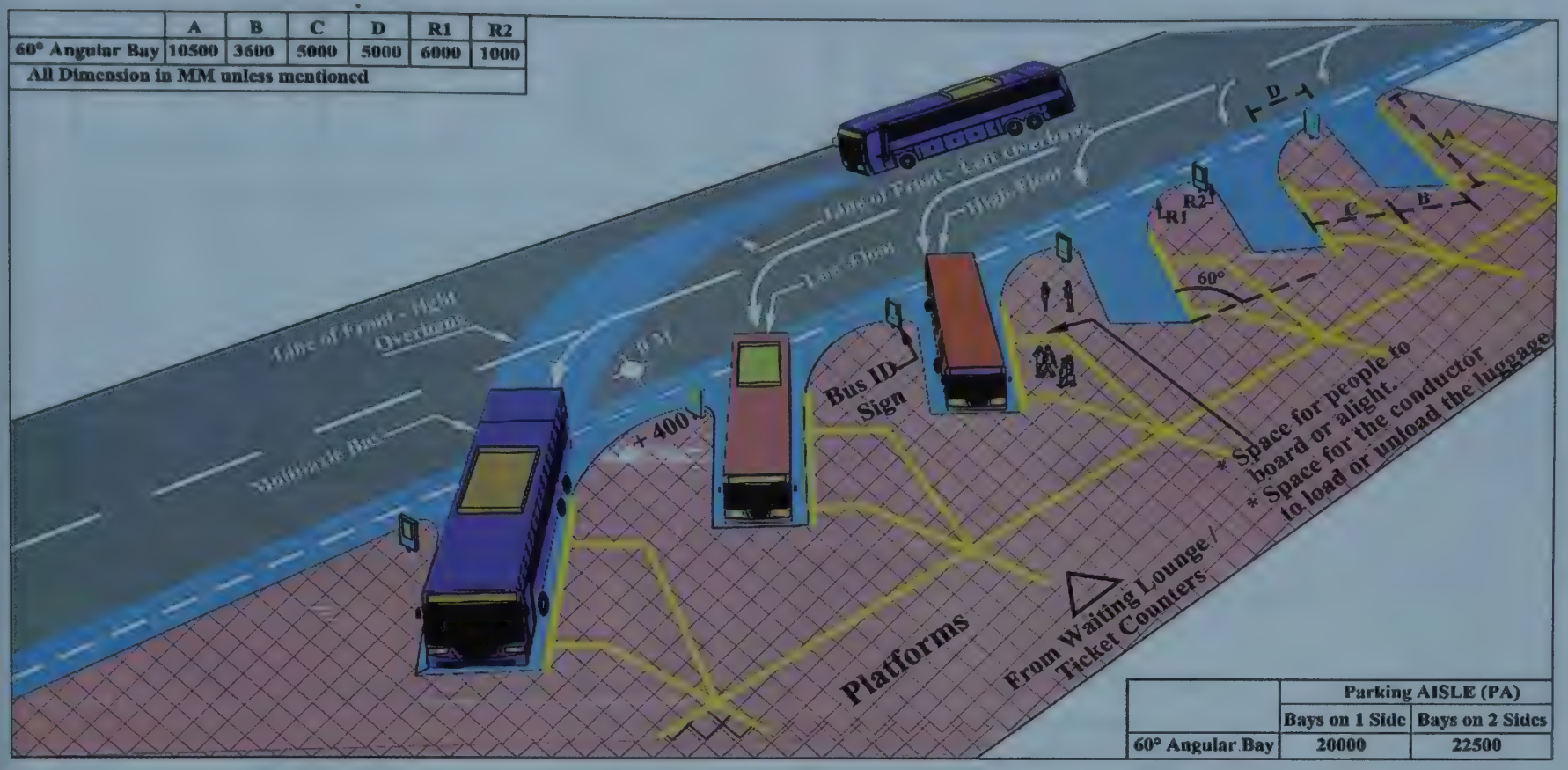
Fig. 4.8 Section through Bus Platforms

	A	B	C	D	R1	R2
45° Angular Bay	1160	3600	5000	5700	8000	1000
All Dimension in MM unless mentioned						



	Parking AISLE (PA)	
	Bays on 1 Side	Bays on 2 Sides
45° Angular Bay	17500	20000

Fig. 4.9 Standard Dimensions for Angular (45 degree) Bays

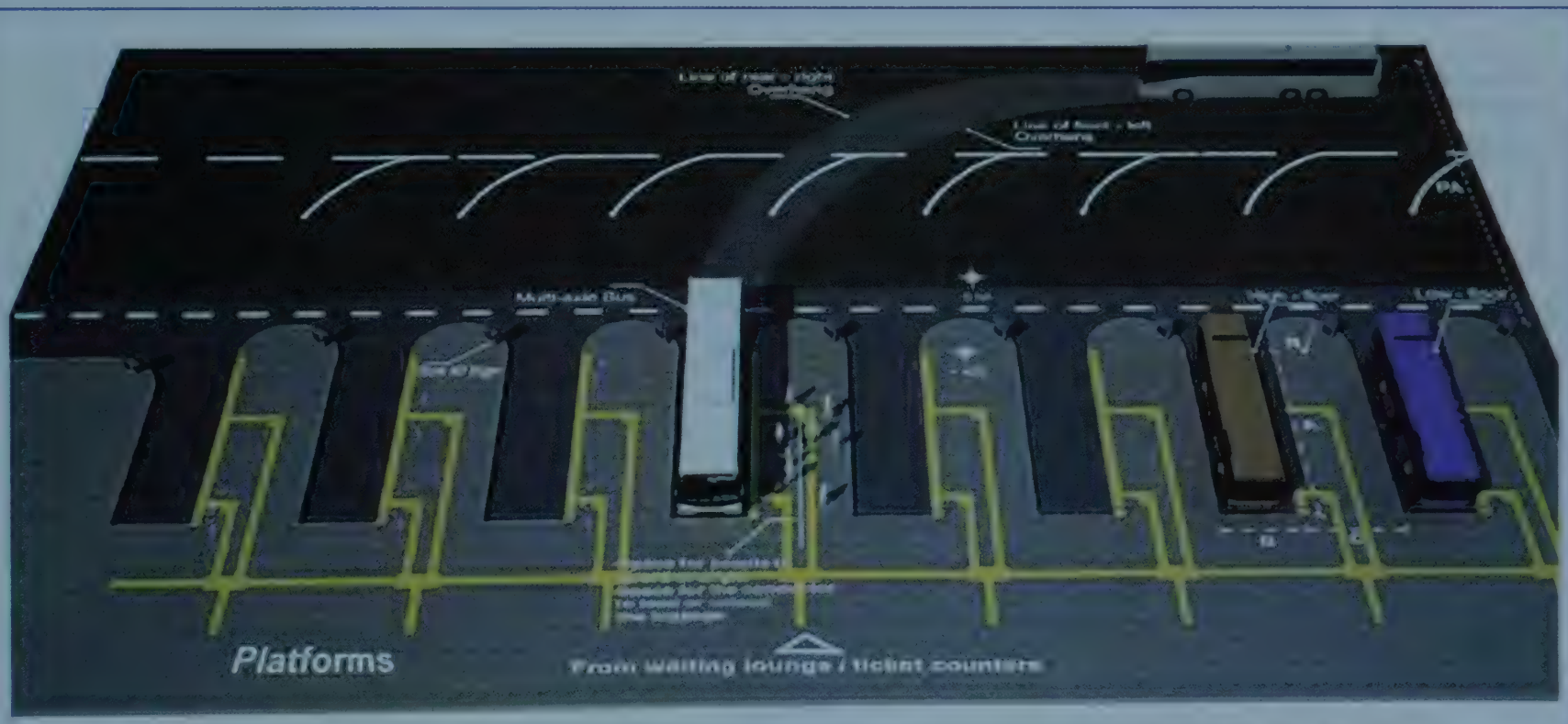


	A	B	C	D	R1	R2
60° Angular Bay	10500	3600	5000	5000	6000	1000

All Dimension in MM unless mentioned

	Parking AISLE (PA)	
	Bays on 1 Side	Bays on 2 Sides
60° Angular Bay	20000	22500

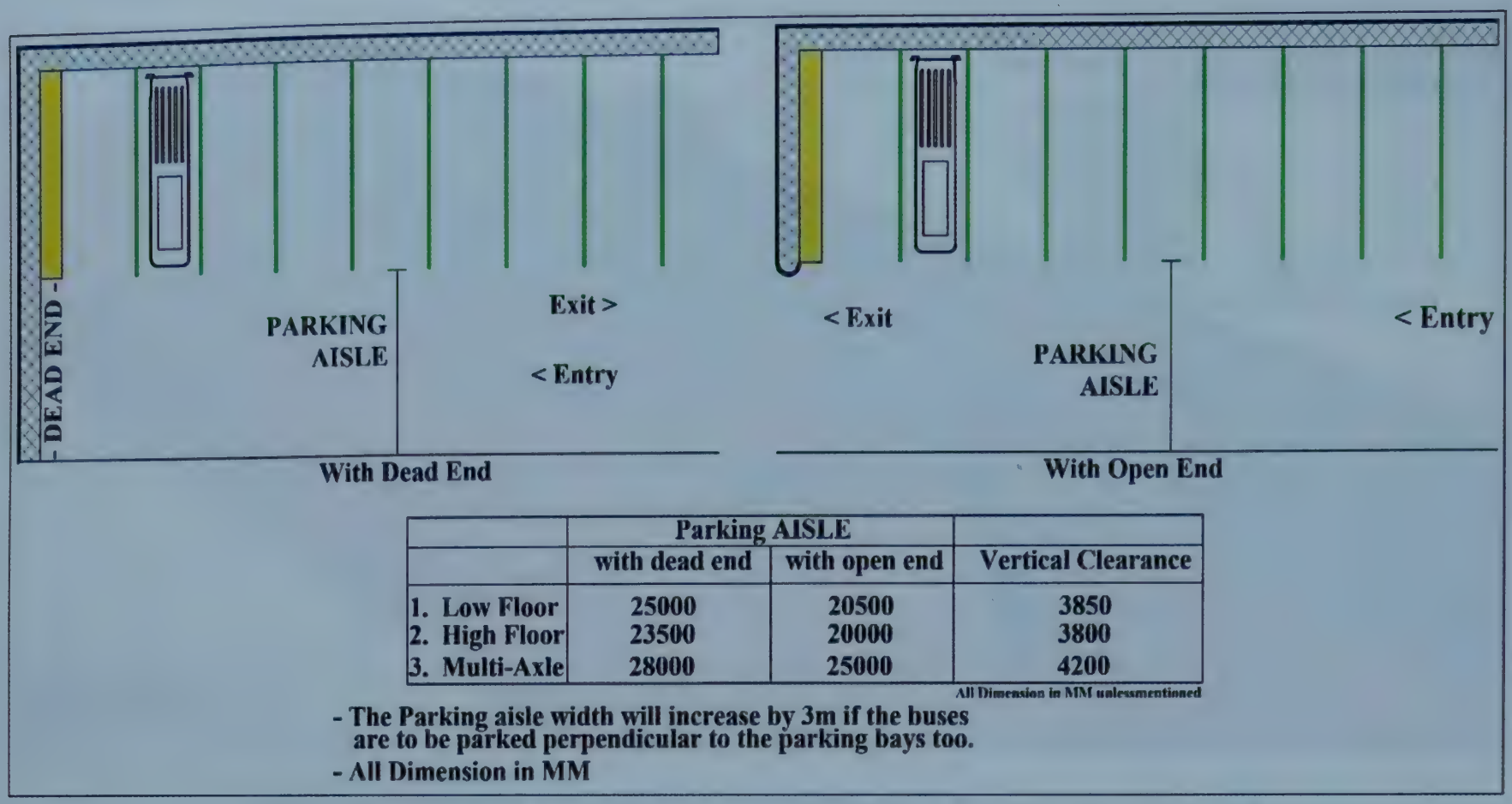
Fig. 4.10 Standard Dimensions for Angular (60 degree) Bays



	A	B	C	D	R
90° Angular Bay	12000	4100	5000	-	2500

	PARKING AISLE (PA)	
	Bays on 1 side	Bays on 2 sides
90° Angular Bay	25000	27500

Fig. 4.11 Standard Dimensions for Angular (90 degree) Bays



	Parking AISLE		
	with dead end	with open end	Vertical Clearance
1. Low Floor	25000	20500	3850
2. High Floor	23500	20000	3800
3. Multi-Axle	28000	25000	4200

All Dimension in MM unlessmentioned

- The Parking aisle width will increase by 3m if the buses are to be parked perpendicular to the parking bays too.
- All Dimension in MM

Fig. 4.12 Standard Dimensions for Bus Parking

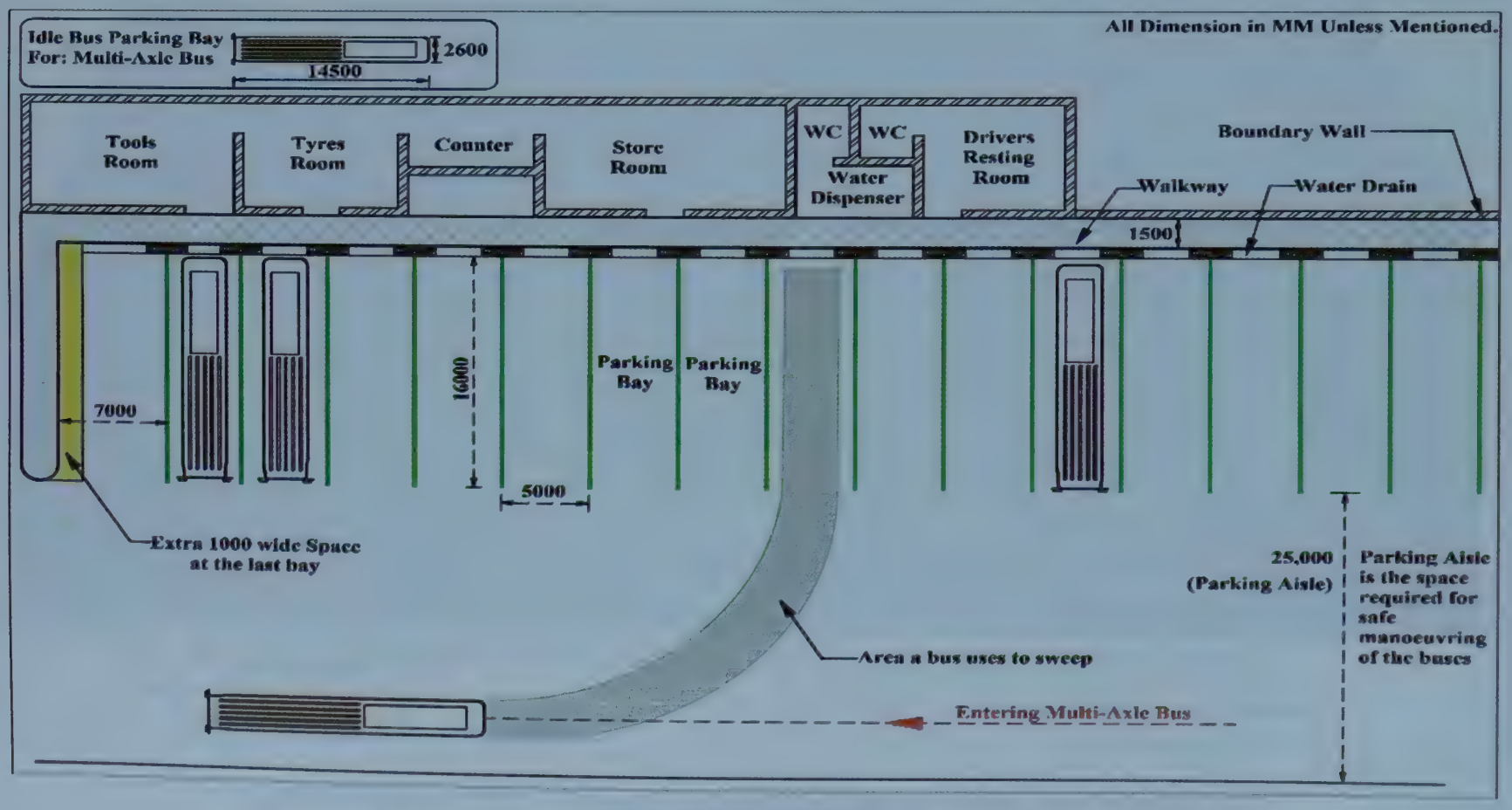


Fig. 4.13 Standard Dimensions for Multi-Axle Bus Parking

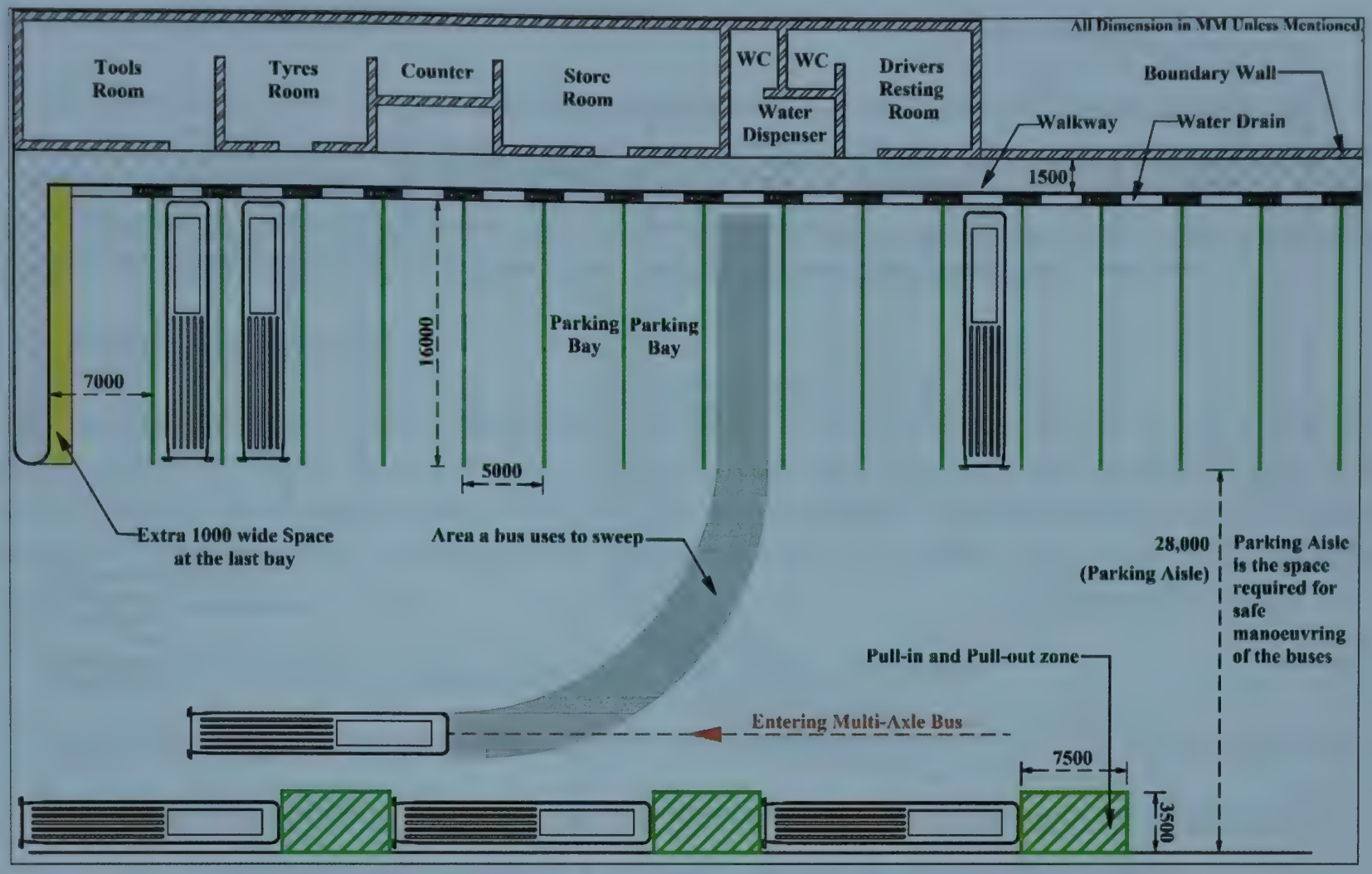


Fig. 4.14 Standard Dimensions for Multi-Axle Bus Parking with Parallel Bays

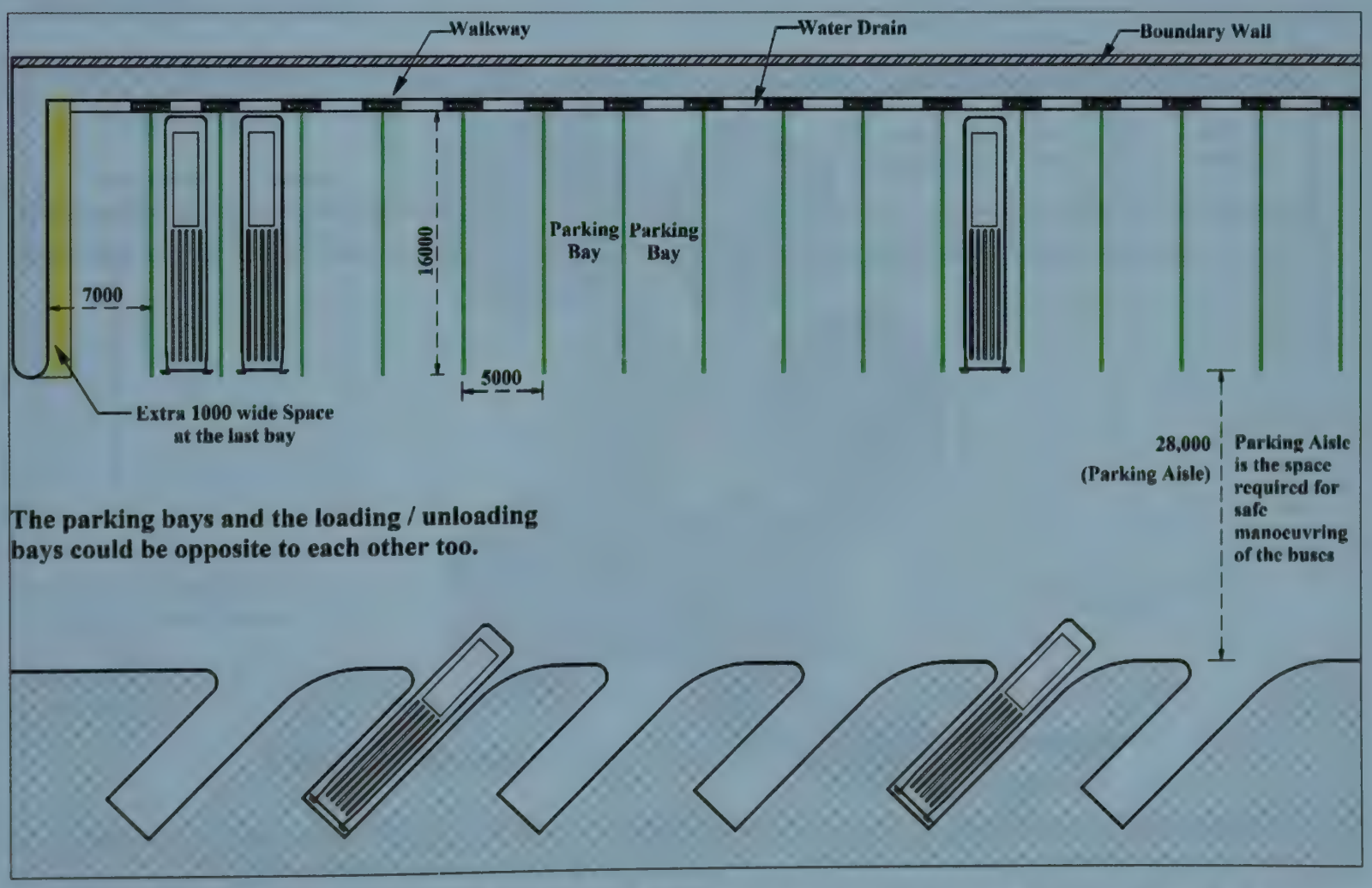

Walkway
Water Drain
Boundary Wall
16000
Parking Bay
Parking Bay
7000
5000
Extra 1000 wide Space at the last bay
28,000 (Parking Aisle)
Parking Aisle is the space required for safe manoeuvring of the buses
The parking bays and the loading / unloading bays could be opposite to each other too.

Fig. 4.15 Standard Dimensions for Bus Parking with Angular Bays

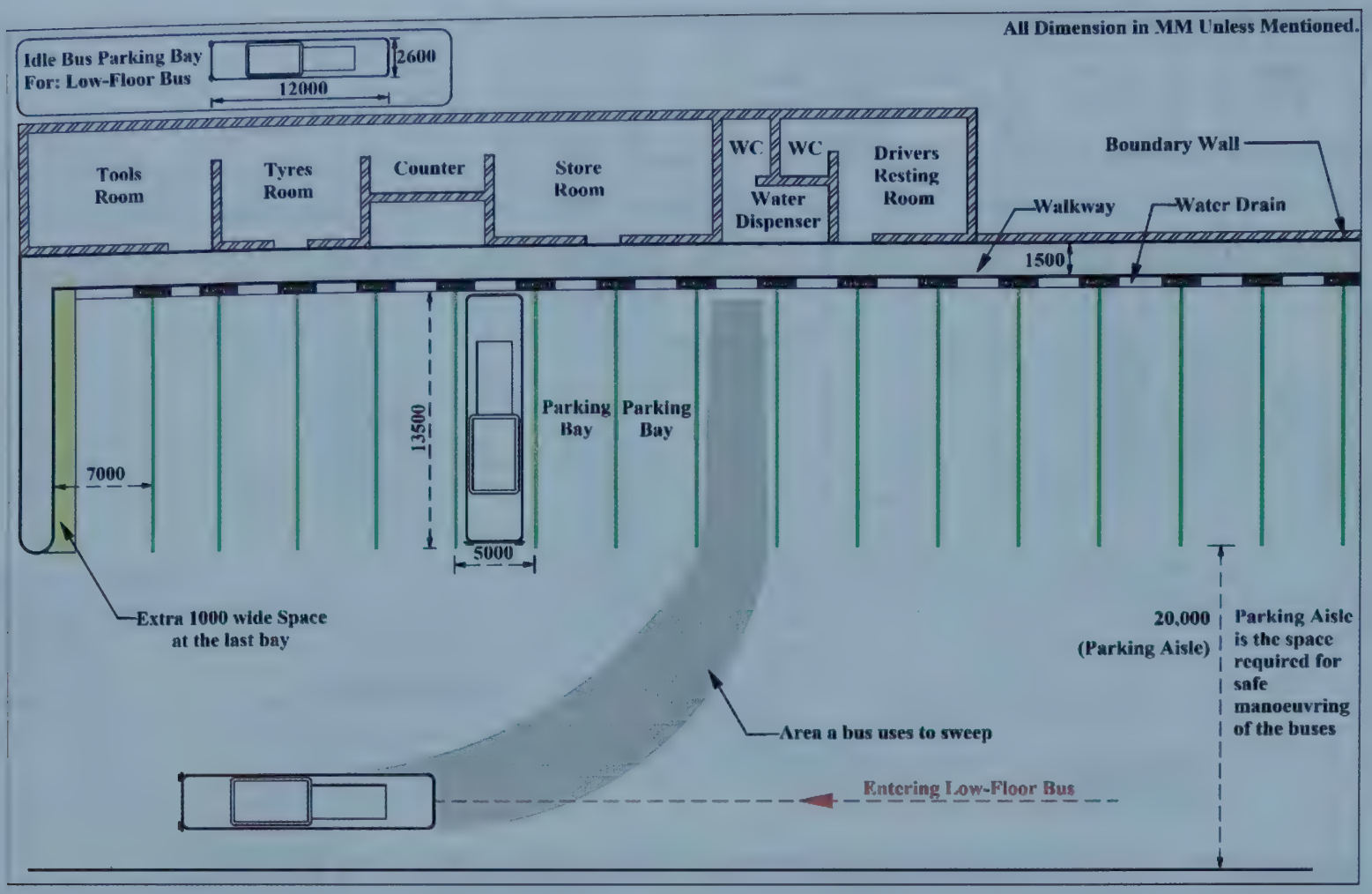


Fig. 4.16 Standard Dimensions for Low-Floor Bus Parking

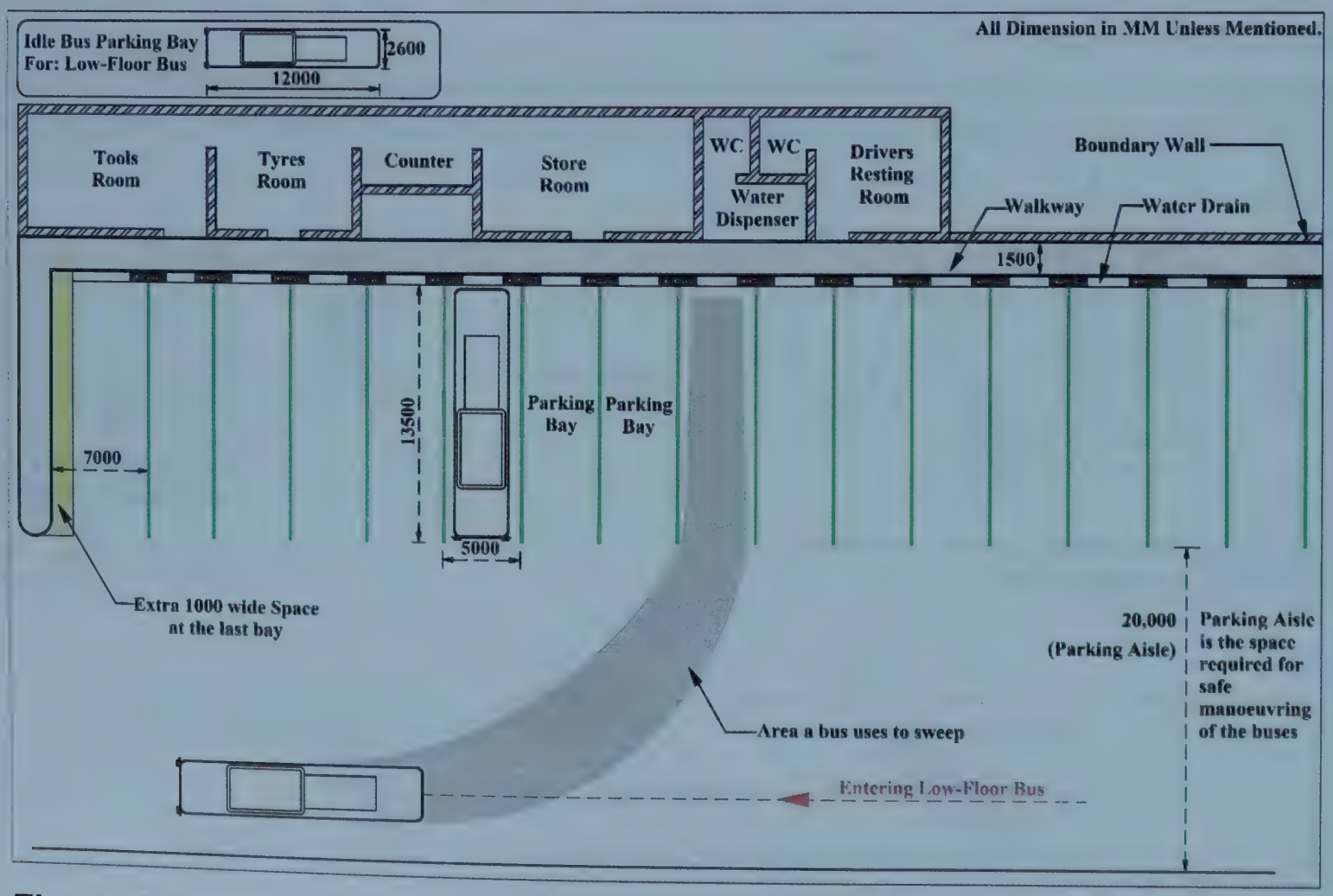


Fig. 4.17 Standard Dimensions for Low-Floor Bus Parking with Parallel Bays

5. PLANNING AND DESIGN OF PASSENGER AMENITIES

This Chapter describes various multimodal integration in bus port facilities, universal access planning considerations to make the facilities accessible to all. This Chapter also highlights the importance of travel information and types of signage to be placed strategically in the bus port to guide the passengers. Besides, this Chapter includes various safety and security arrangements in and out of the bus port to facilitate the passengers using the facilities.

5.1 Multimodal Integration

Multimodal integration is vital to facilitate users for their ease of access to a bus port and improve transfer conditions and time between modes. If planned and managed well, this can surely improve "door to door travel time" and "last mile connectivity" for public transport users and may also attract choice riders towards public transport. This integration **(Fig. 5.1)** can be achieved through:

- Institutional integration (such as an umbrella transit authority)
- Operation integration (such as an authority overlooking more than one transit operation)
- Fare integration (where fares for various services, especially transit, are integrated)
- Information integration (where information for various services, especially transit, is integrated)
- Modal integration (where various modes of transit are physically integrated)

Fig. 5.1 Degrees of Connections for Bus Port Sites

In the absence of adequate planning of multimodal access, the overall passenger trip chain can get affected, which in turn reduce the level of service for users of the bus port, and as a

consequence, partial or total disregard by its users and induce a shift to other transport modes, preferably to private vehicles.

Therefore, an integrated design emphasizing the bus ports' multi-modality would act as the interface between different modes. This approach includes convenient, well-designed pedestrian facilities, universal access to the elderly, children, people with diverse abilities; port amenities for passengers, etc.

The selection of access mode by users depends on four major aspects such as availability of route from the point of origin; accessibility in terms of physical ability to use the mode; affordability of the commute; and reliability and time savings related to the mode in terms of frequency, predictability, and safety. However, these cannot be solely controlled by the planning and design of a bus port as it also depends on larger public transport systems of the city, the factors that would affect the usage of public and paratransit modes for access are dependent on the ease of inter-modal exchange. This is directly related to the distance between the modes and inversely proportional to the number of conflicts in terms of crossings and grade separations to deliver the least amount of time spent on the interchange.

5.1.1 *Planning Parameters for Multi-Modality*

While planning for multi-modality, higher priority to more resource-efficient modes should be given over single-occupant automobile travel, particularly on congested urban corridors. This provides a basis for shifting emphasis in transport planning, road space allocation, funding, and pricing to favor more efficient modes. Prioritization would include locating or integrating other modes closer to the bus port and reducing conflict points and grade separations while accessing the bus port from that particular mode.

5.1.2 *Bus Port Connectivity and Segregation of Circulation Paths*

Sites available for a bus port may have three levels of connectivity with the city, as seen in **Fig. 5.2**. At the highest order would be a site that has access roads on opposite sides (A), a median order with access roads on adjacent edges of the site (B), while at the lowest order, an access road only of one edge of the site (C).

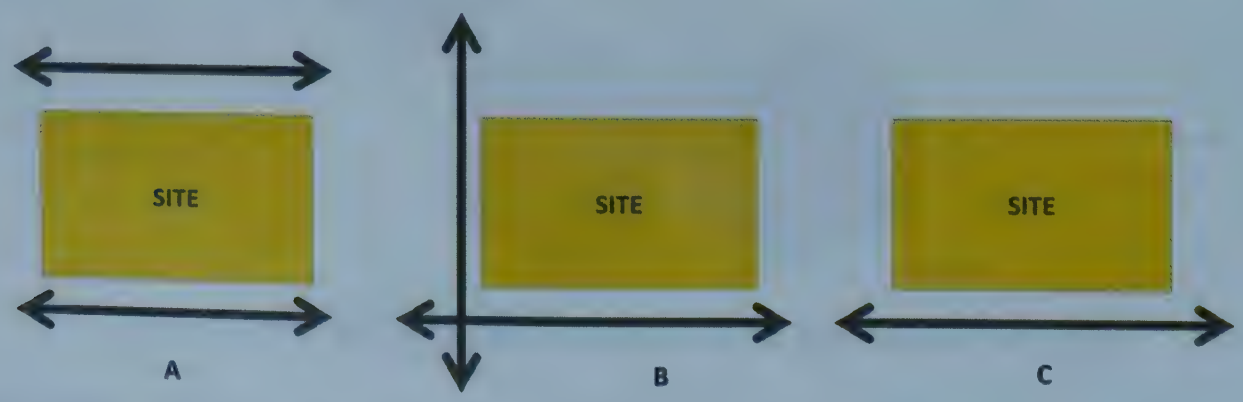


Fig. 5.2 Degrees of Connections for Bus Port Sites

In the planning of a bus port, the schematic zoning of a bus port site would be done as shown in **Fig. 5.3**.

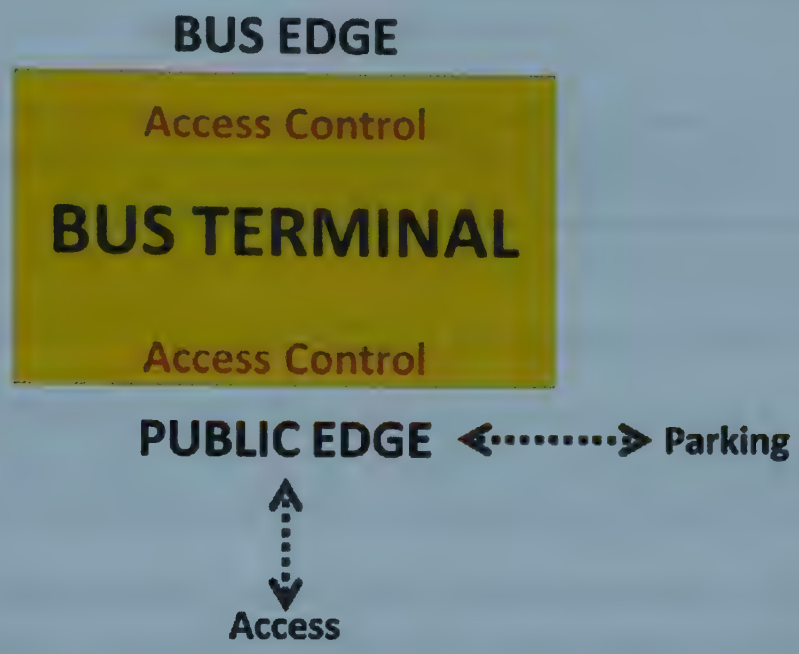


Fig. 5.3 Schematic Zoning for a Bus Port Building

Based on the schematic shown in **Fig. 5.3**, various access conditions can be designed to segregate the circulation of buses, passengers, and access modes.

As seen in **Fig. 5.4**, access roads on opposite sides allow complete segregation (a), access roads on adjacent sides allow segregation for the most part but with a degree of conflict between the access modes and buses (b), while in the last option, a single access road suffers from conflict both at the entrance and the exit.

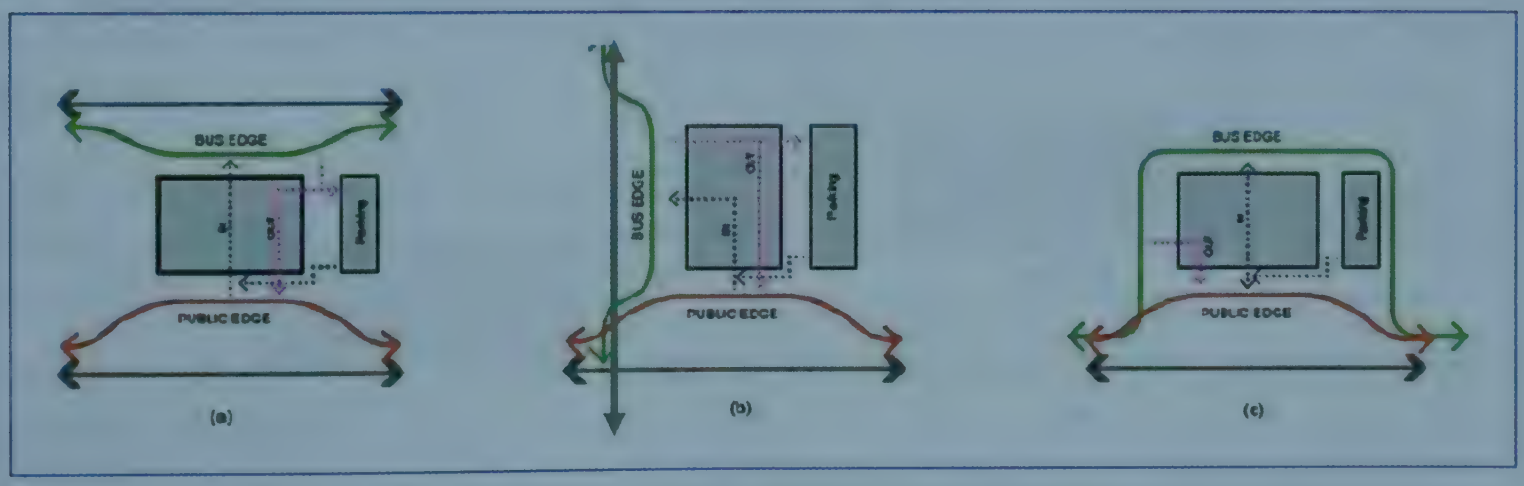


Fig. 5.4 Access Conditions Depending On-Site Access

In scenarios with a potential conflict, the entries/exits of the various modes would need to be separated from each other, allowing enough space for merging and diverging the various modes. Besides, the area should be traffic-calmed to reduce dangerous situations of conflict between the modes. When vehicles are moving at slower speeds at these intersecting circulation paths afforded by the calming measures, there would be a smoother flow as the arrival rate of vehicles at the conflict points would be controlled.

In addition to horizontal segregation of movement systems, in space-constrained scenarios or where the size of the bus port is large and therefore high footfall and number of vehicles, options for vertical segregation may also be explored.

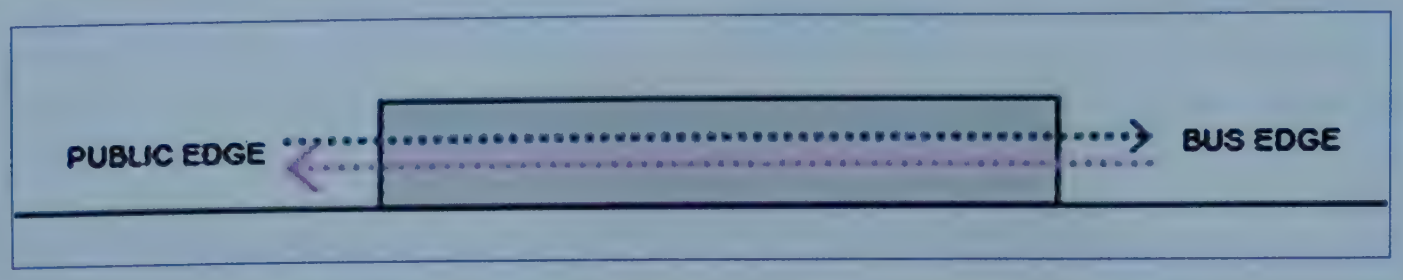


Fig. 5.5 Basic Horizontal Segregation of Circulation

The below illustrations (**Fig. 5.6**) explore the segregation of passengers arriving and departing in the building based on basic horizontal circulation as seen in **Fig. 5.6**. This would allow for dispersal at various levels and reduce the number of access vehicles at the same location.

In situations where parking is catered to within the building itself, either due to lack of sufficient ground space or due to the requirement of a higher number of parking consequences to commercial development, segregation can be catered to as seen in **Fig. 5.7**, either with vertically stacked or basement parking.

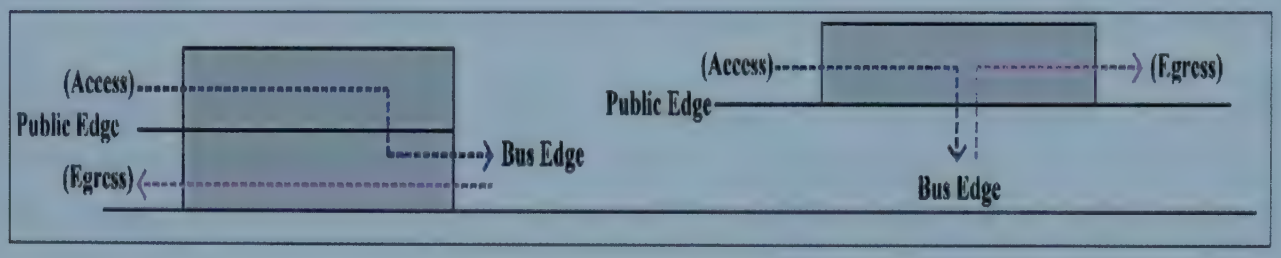


Fig. 5.6 Segregation of Access and Egress through Grade Separation

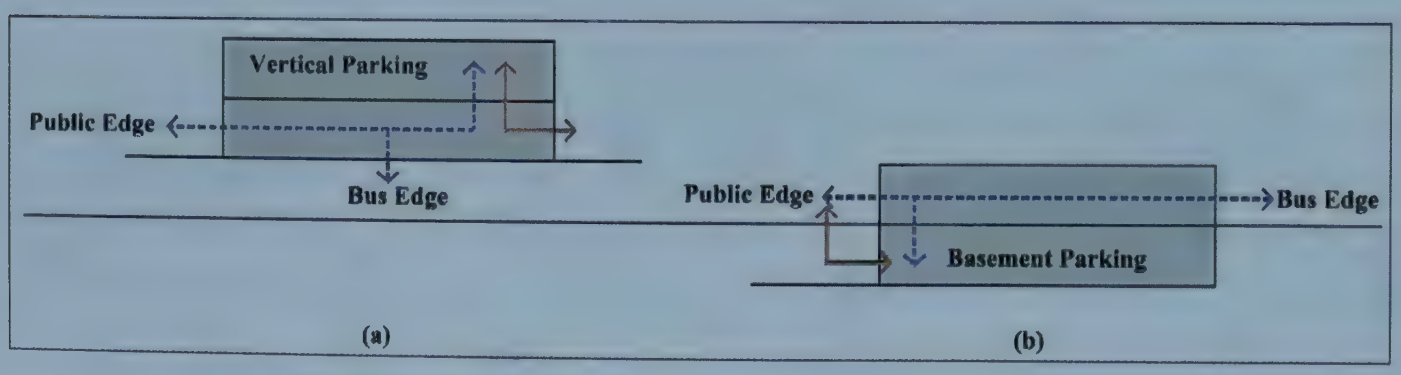


Fig. 5.7 Segregation of Park & Ride from Other Circulation

5.1.3 *Physical Integration*

In addition to facilitating inter-modality by limiting distance and grade separation, it is imperative to plan for high-quality pedestrian infrastructure since all modes, whether public transit, pick & drop, or park & ride, can only be made possible a safe, convenient and comfortable pedestrian network.

(i) Accessibility of Footpaths

- Footpath should have a convenient height such that it is easily accessible by aged people and children.
- Footpath should be accessible to people in a wheelchair by providing ramps with suitable gradients of a maximum of 1:12 and desirable 1:15.
- At the ingress and egress to a footpath, special surfaces such as tactile pavement should be provided for visually impaired guidance.

(ii) Accessibility of Pedestrian Crossing

- Pedestrian crossings should be at the same level as the footpath for easy access for all.
- Ramps should be provided at the transition between the footpath and pedestrian crossing when the pedestrian crossing cannot be at the same level as the footpath.
- Handrails should have an opening leading to the crosswalk and should have a width of at least the crosswalk width.
- At a signalized pedestrian crossing with pedestrian pushbuttons, the pushbuttons should be aligned to be comfortably accessible to people on wheelchairs.

(iii) Accessibility of Subways and Foot-Over-Bridges

- All subways and FOBs should have elevators in addition to stairs. Elevators are essential at all grade-separated pedestrian crossings for the mobility of differently-abled on the wheelchair.
- Escalators may be provided along with stairs to increase comfort, but it cannot be a replacement to elevators, as escalators cannot safely accommodate pedestrians on the wheelchair.
- Elevators should have enough space to accommodate at least one wheelchair and a pedestrian to stand.
- Opening to subways and FOBs should have sufficient width to allow two people to cross each other comfortably.

The parameters to be considered for designing quality pedestrian movement spaces are listed below:

- Walking space of minimum 4.0 m width and 2.4 m height
- The dead zone of 1.0 m width

- Continuous sidewalk
- Maximum kerb height of 150 mm
- Table-top crossings to avoid grade changes
- Ramps of maximum 1:12 gradient where not possible to maintain the same grade
- Traffic calming to maintain a maximum vehicular speed of 20-25 km/h at intersections to improve pedestrian safety
- Accessible infrastructure through tactile paving and auditory signals
- Pedestrian lighting for night time safety

For more details, refer to IRC:103 "Guidelines for Padestrian Facilities"

5.1.4 *Variations in Multimodal Integration*

The ease of multi-modality is best measured in the time taken to switch between modes. In an ideal scenario, vertical integration between major modes should be preferred. This can happen in three variations listed from best to acceptable.

Vertical Integration: Combined development allowing vertical integration of passenger spaces **(see Fig. 5.8)**.

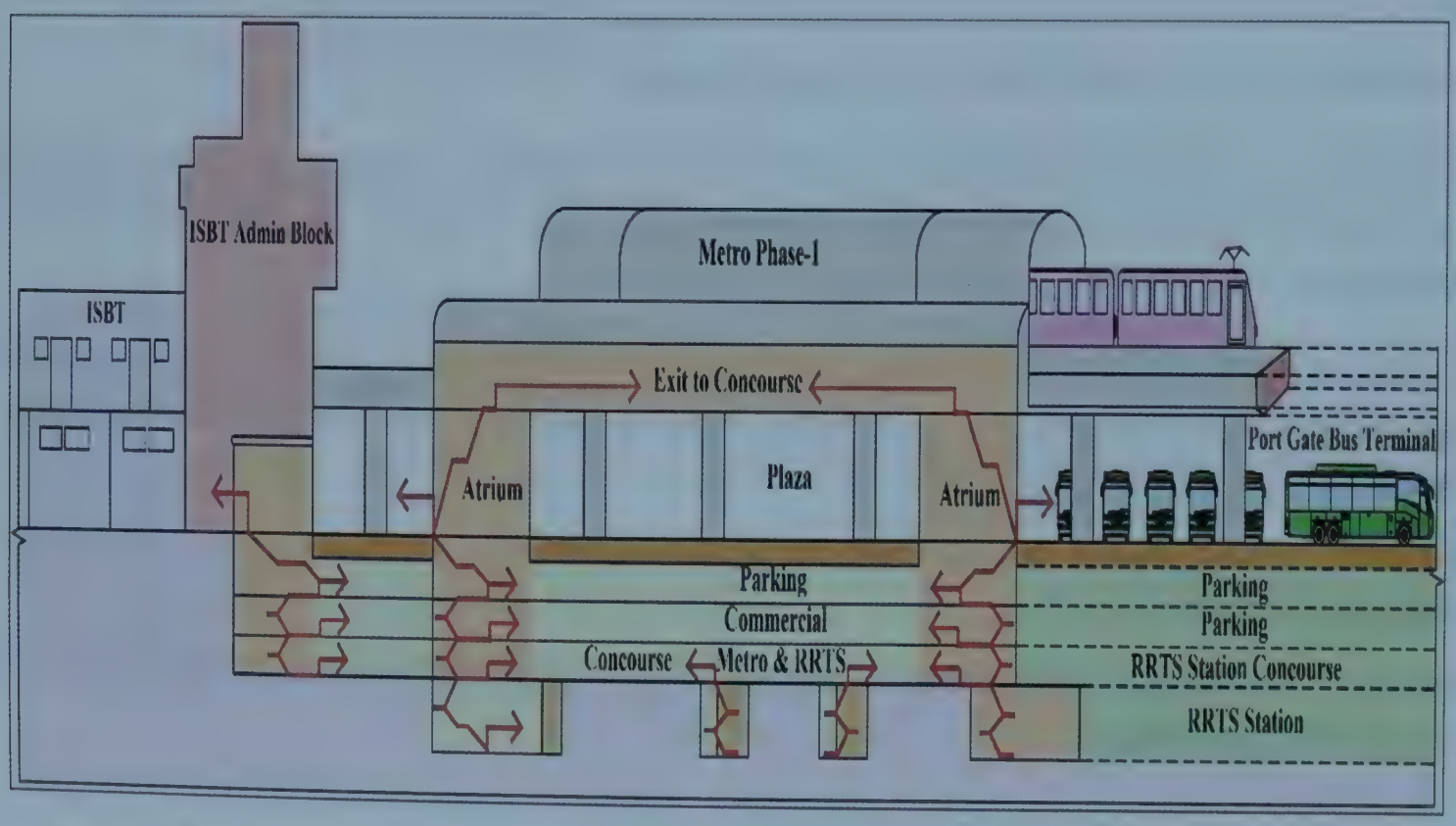


Fig. 5.8 Vertical Integration - Kashmere Gate RRTS to ISBT and Metro

Horizontal Integration: Integrated planning allowing horizontally separated modes to be as near as possible and simultaneously facilitating passenger interchange without multiple grade changes **(See Fig. 5.9)**.

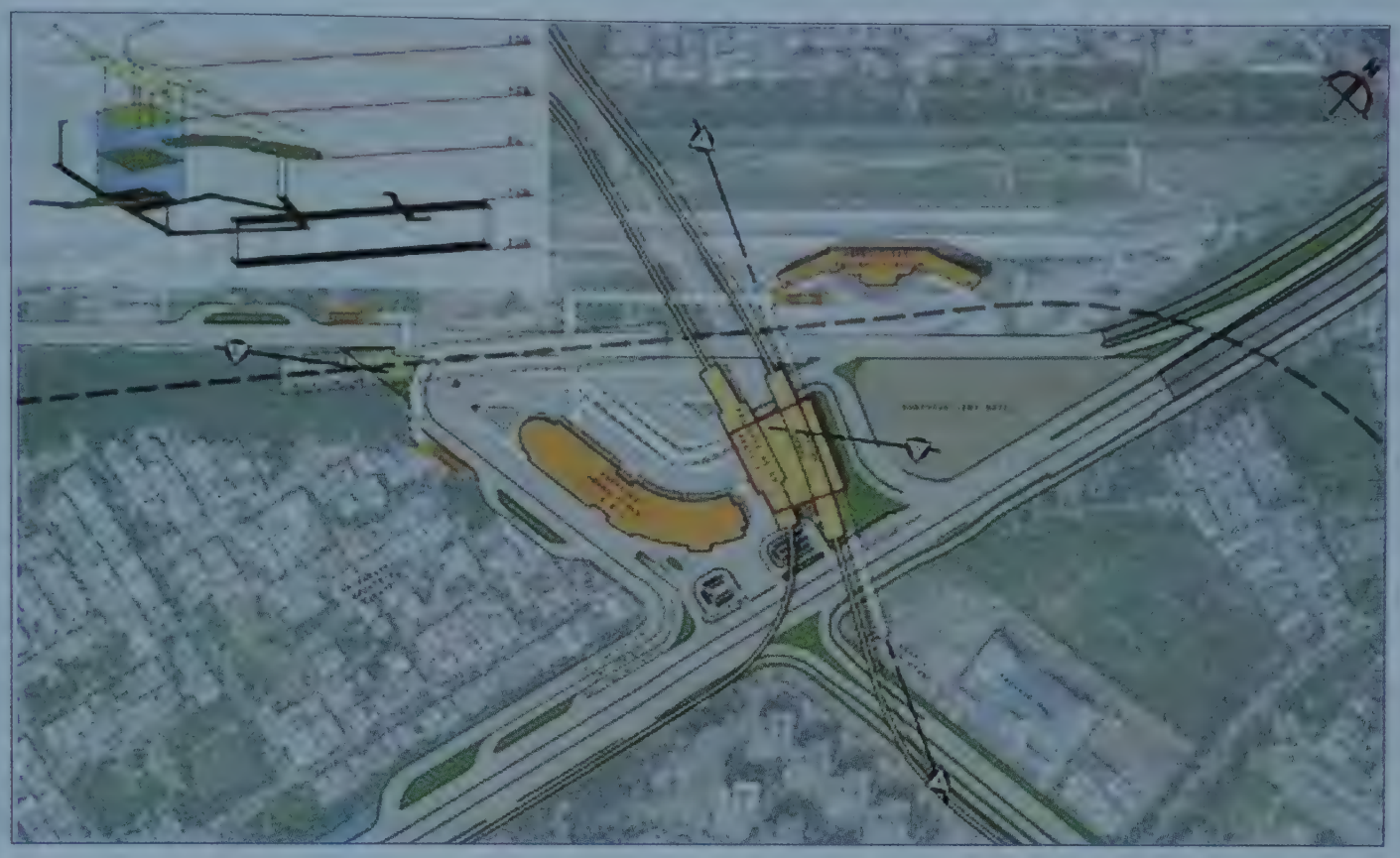


Fig. 5.9 Horizontal Integration - Anand Vihar RRTS to ISBT, Metro & Railway Station

Integration of Modes across Barriers: Modes separated by a distance knit together by continuous, uninterrupted pedestrian infrastructure and, if necessary, a feeder system facilitated by paratransit **(See Fig. 5.10)**.

Fig. 5.10 Integration of Modes Across Barriers at Welcome Metro Interchange Station

5.1.5 *Efficiency Calculation for Multimodal Integration*

Efficiency calculation to measure integration between modes are dependent on 2 aspects:

(i) Time of Access

(ii) Ease of Access

(i) Time of Access

Four aspects govern the time of access for inter-modality:

- Distance between modes
- Number of conflict points (crossings)
- Number of grade separations
- Total change of height

To achieve the outcomes listed above, the calculation of the aspects may be estimated as follows **(Table 5.1)**:

Table 5.1 Parameters for Calculating Efficiency of 'Time of Access' between Modes

Parameter	Efficiency
Walking	1.33 m/sec
Street Crossing	15 sec upto 20 m ROW
Street Crossing (signalized)	As per signal design
Stairs	0.35 m/sec
Escalator	0.4-0.6 m/sec
Elevator	0.6-1.0 m/sec (including waiting time may be considered 0.3-0.6 m/sec)

NOTE: The above Figs. are estimated for Walkway Level of Service (LOS) C i.e. 0.43-0.72 pedestrians per square metre allowing some restriction in selection of walking speed and ability to cross others with a flow rate of 34 to 49 pedestrians per metre per minute. In case of reduction in LOS, additional time would need to be estimated. Further, since a bus port would generally have passengers with luggage, a 25% reduction in efficiency may be considered.

Using the parameters specified above, the time taken from the bus port entrance to the interchange mode should be as follows **(Table 5.2)**:

Table 5.2 Level of Service for Time of Interchange between Modes

Type of Mode	Time of Interchange (in minutes)				
	LOS A	LOS B	LOS C	LOS D	LOS E
Public Transit	0.5	1.0	1.5	2.0	2.5
Pick and Drop	1.5	2.0	2.5	3.0	3.5
Park and Ride	3.5	4.0	4.5	5.0	5.5

(ii) Ease of Access

While the time of access is an essential measure of efficiency, ease of access is an important parameter as the perception of the particular mode often governs mode selection. This is evaluated by two aspects, the wayfinding associated with the mode and the actual physical ease of access.

The basic process of wayfinding involves four stages:

- **Orientation** is the attempt to determine one's location, in relation to objects that may be nearby and the desired destination
- **Route decision** is the selection of a course of direction to the destination
- **Route monitoring** is checking to make sure that the selected route is heading towards to the destination
- **Destination** recognition is when the destination is recognized

In complex environments, wayfinding is aided by signage and/or colour coding and is an important aspect of universal access. Ease of access by wayfinding may be measured as follows **(Table 5.3)**:

Table 5.3 Level of Service for Ease of Access through Wayfinding

Parameter	Ease of Access (Wayfinding)				
	LOS A	**LOS B**	**LOS C**	**LOS D**	**LOS E**
Number of direction changes	0 no. OR 1 no. aided with signage/ colour coding	1 no. OR 2 nos. aided with signage/ colour coding	3 nos. aided with signage/ colour coding	4 nos. aided with signage/ colour coding	5 nos. aided with signage/ colour coding

While planning and designing for wayfinding would be extremely site specific, physical ease of access may be measured with the following parameters **(Table 5.4)**.

Table 5.4 Level of Service for Ease of Access through Grade Separation

Parameter	Ease of Access (Grade separation)				
	LOS A	LOS B	LOS C	LOS D	LOS E
Stairs	No grade separation or conflict	Minor at-grade conflicts	1 no. grade separation <3 m with Stairs	1 no. grade separation 3-5 m with Stairs OR 2 nos. grade separations <3 m each with Stairs	1 no. grade separation >5 m with Stairs OR 2 nos. grade separations 3-5 m each with Stairs OR >2 nos. grade separations with Stairs
Escalators	No grade separation or conflict	1 no. grade separation <5 m with Escalators	1 no. grade separation 5-8 m with Escalators OR 2 nos. grade separations <5 m each with Escalators	1 no. grade separation >8 m with Escalators OR 2 nos. grade separations <5 m each with Escalators OR >2 nos. grade separations with Escalators	No escalators
Elevators	No grade separation or conflict	1 no. grade separation <5 m with Elevators	1 no. grade separation 5-8 m with Elevators OR 2 nos. grade separations <5 m each with Elevators	1 no. grade separation >8 m with Elevators OR 2 nos. grade separations <5 m each with Elevators OR >2 nos. grade separations with Elevators	No elevators

NOTE: In the case of elevators, while one elevator must be mandatorily provided for universal access of wheelchair users, the above considerations would only apply in case of elevator capacity in terms of number and size is sufficient for usage by 25% of the users.

5.1.6 *Level of Service for Multimodal Integration*

The Level of Service for Multimodal Integration is given in **Table 5.5**.

Table 5.5 Level of Service for Multimodal Integration

Parameter	Multimodal Integration				
	LOS A	**LOS B**	**LOS C**	**LOS D**	**LOS E**
Time of Interchange to public transit (in min)	0.5	1.0	1.5	2.0	2.5
Time of Interchange to Pick and Drop (in min)	1.5	2.0	2.5	3.0	3.5
Time of Interchange to Park & Ride (in min)	3.5	4.0	4.5	5.0	5.5
Wayfinding (number of direction changes)	0 no. OR 1 no. aided with signage/ colour coding	1 no. OR 2 nos. aided with signage/ colour coding	3 nos. aided with signage/ colour coding	4 nos. aided with signage/ colour coding	5 nos. aided with signage/ colour coding
Grade Separation (*NOTE: In the case of elevators, while they must be mandatorily be provided for universal access of wheelchair users, the considerations would apply only in case elevator capacity in terms of number and size is sufficient for usage by 25% of the users*)	No grade separation or conflict	Minor at- grade conflicts OR 1 no. grade separation <5 m with Elevator/ Escalator	1 no. grade separation <3 m with Stairs OR 1 no. grade separation 5-8m with Elevator/ Escalator OR 2 nos. grade separation <5 m each with Elevator/ Escalator	1 no. grade separation 3-5 m with Stairs OR 2 nos. grade separation <3 m each with Stairs OR 1 no. grade separation >8 m with Elevator/ Escalator OR 3 nos. grade separation 5-8 m each with Elevator/ Escalator OR >2 nos. grade separations with Elevator/ Escalator	1 no. grade separation >5 m with Stairs OR 2 nos. grade separation 3-5m each with Stairs OR >2 nos. grade separation with Stairs

5.2 Universal Access

Universal access plays a crucial role to create an inclusive public facility. Extending accessibility options to the elderly, mobility impaired, audibly impaired and visually challenged is significant in ensuring good quality service. Reference standards, regulations and codes for the same may be sought from Persons with Disability Act, ADA Accessibility Guidelines for Buildings and Facilities (ADAAG) and the National Building Code. All entries & exits and pedestrian spaces should follow the standards for universal access as set by the National Building Code. This includes ramps, tactile pavers, special provision for handicap parking and drop off among other mandatory provisions for making the bus port building seamlessly accessible for differentially abled citizens. The entry spaces within the building and entry courts outside should be designed taking into account that the passengers might have rolling suitcases, luggage carts and perambulators. Therefore, extremely rough surfaces or steep slopes should be avoided.

5.2.1 *Pedestrian Access*

Safety of the pedestrians entering and egressing the bus port on foot from the street, bicycles, cycle rickshaws & other non-motorized transport modes, mass transit systems like Bus Rapid Transit or Metro and car parking & car drop off should be the highest priority along with bus maneuverability in bus port design. Special care should be taken to consider the access of pedestrians from the opposite side of the thoroughfare on which the bus port sits. An understanding of existing and proposed land uses as well as activity patterns around the site and across the thoroughfare is important to design the public realm which is integrally connected to the design of the pedestrian path on the site. The principles to be considered while designing for pedestrian access are as follows:

a) Design pedestrian access according to desire lines i.e. the path with the shortest distance between point A to point B is the path that pedestrians will tend to take to travel from A to B, whether it is designated for pedestrian or not. Therefore, wherever possible, make sure that these direct shortest paths from car parking or drop offs or across the street are developed and designed for pedestrian use.

b) Wherever possible, minimize conflict between pedestrian movement and movement of any other mode, with priority to the direct movement of the pedestrian.

c) Emphasize, demarcate and use traffic calming and pedestrian safety measures wherever there is a conflict between pedestrian movement and vehicular movement. Signalization can also be an option where traffic volumes are heavy but a grade separation is not appropriate.

d) Grade separation may be inevitable in cases where traffic volumes and/or vehicle speeds are high. The grade separation to be provided should be convenient, well- lit and safe. Some ways of doing this are - connecting the grade separated pathway directly to the bus port building (e.g. directly to the concourse floor or a dedicated entry plaza); integrating retail, concessionaires or other activities to the grade separated walkway; and providing escalators and lifts.

5.2.2 *Entries and Exits*

The following principles should be followed while designing pedestrian entry and exit points.

(i) Pedestrian Entries and Exits

Make sure pedestrian entries and exits are demarcated clearly and the entry spaces of the bus port building should be wide, direct, transparent and noticeable. The porch as well as other sides of the building should have a provision for affixing the bus port name. Care should be taken to ensure that it can be lit up at night and can clearly be read from the thoroughfare, on foot and within the bus.

(ii) Entry Courts

Entry courts can be of different sizes, either along the longer side of the bus port or along the secondary/shorter edges. However, these courts should integrate the following:

- Passenger Information System for dissemination of bus departure and arriving information
- Shade giving landscape that does not obstruct view of bus port and its signage
- Street furniture
- Lighting
- Seating ledges
- Bicycle parking and
- Provision for accommodating informal street vendors.

Secondary courts can also be developed as service access areas for pickup trucks associated with service or delivery.

(iii) NMT or IPT

The primary 'pick up' and 'drop off' spaces used by public transit, NMT or IPT, should ideally be located on the curb side of these major entry courts/spaces. Car drop off can also be located in this area if space is manageable, however, spaces for handicapped parking/drop off should be provided in these spaces. For managing the drop off of all these modes, it is recommended that the bus port site develop a long primary curbside entry which can facilitate the pulling in and pulling out of all these transport modes.

(iv) Car Drop off and Parking

Car drop off and parking can be provided on another/secondary side of the bus port with its own dedicated entry space and porch. It is recommended that these pick up and drop off spaces have provision for shade (from sun) and rain by means of pavilions, light tensile roofs etc.

(v) Pick-up and Drop off Lane

The pick-up and drop off lane along the primary edge/entry court of the bus port should have appropriate traffic calming devices including a combination of road marking and signage. No-parking zones should be clearly indicated both on the road surface and as traffic signage.

(vi) Visibility Impairment Zones

Consider visibility impairment zones of the buses while designing pedestrian access and entry & exit of buses is given in **Fig. 5.11**.

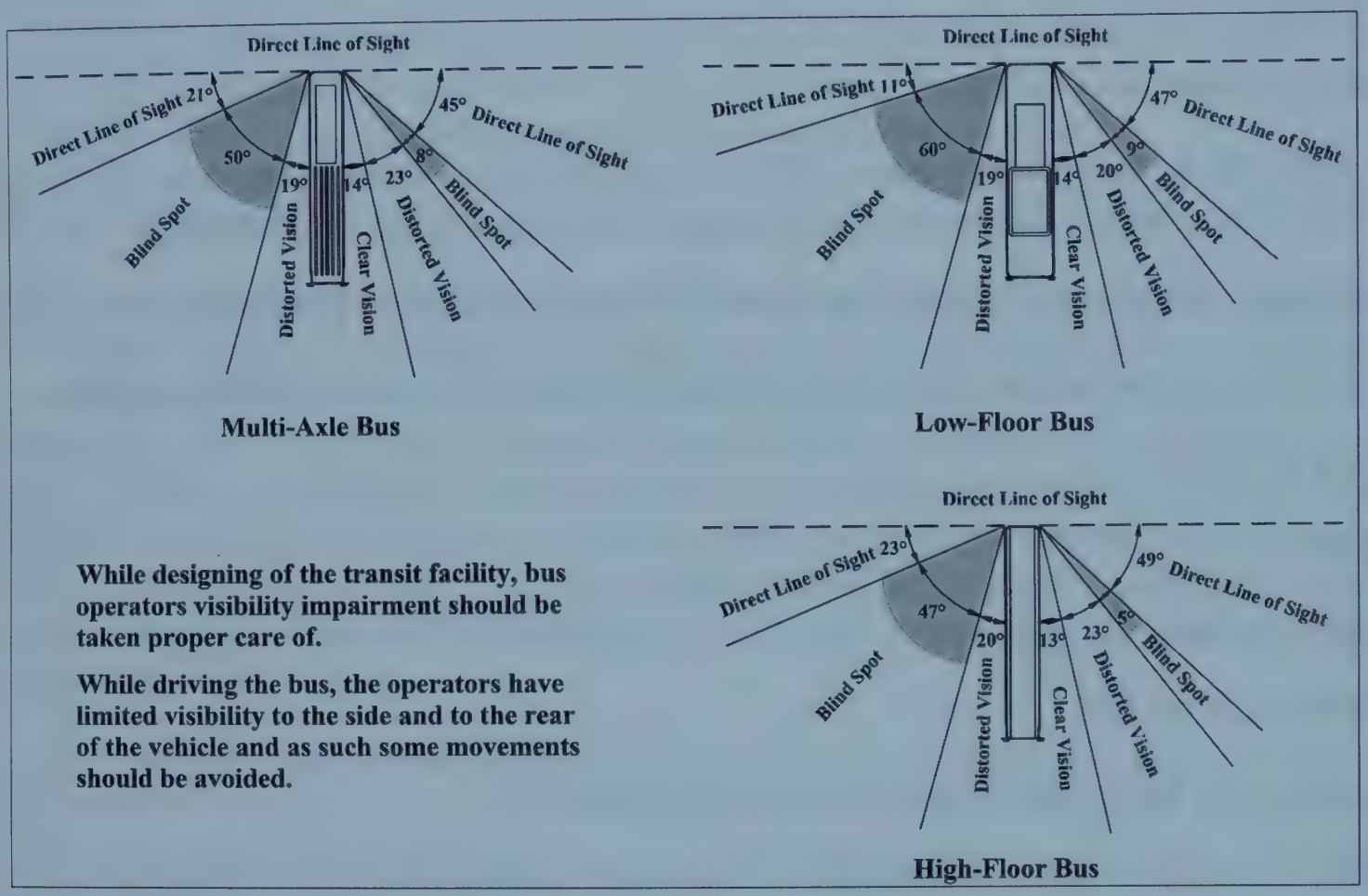


Fig. 5.11 Sight Angles for Buses

5.2.3 *Designing for the Visually Impaired*

It is important to keep main movement paths obstruction free. In case any furnishings are provided such as freestanding signs, telephone enclosures or fire hose cabinets, they shall be cane detectable and protected.

- Tactile guide paths should be strategically placed to lead the visually impaired passengers from the access points to ticket office, ticket vending machines, control gates, access to restrooms, restaurants, and then to the handicap friendly passenger lifts.
- Tactile guiding blocks may be placed 300 mm away from the ticket vending machine. Floor indicators on the elevator exteriors shall have tactile/Braille signage. All escalators should be fitted with audible indicators to warn the visually impaired passengers.

- Tactile hazard markings shall be provided at danger areas such as escalator landings, stairwells and passenger lift access.

The following **Fig. 5.12** represent recommended configurations for laying out tactile pavers in bus bay landing areas.

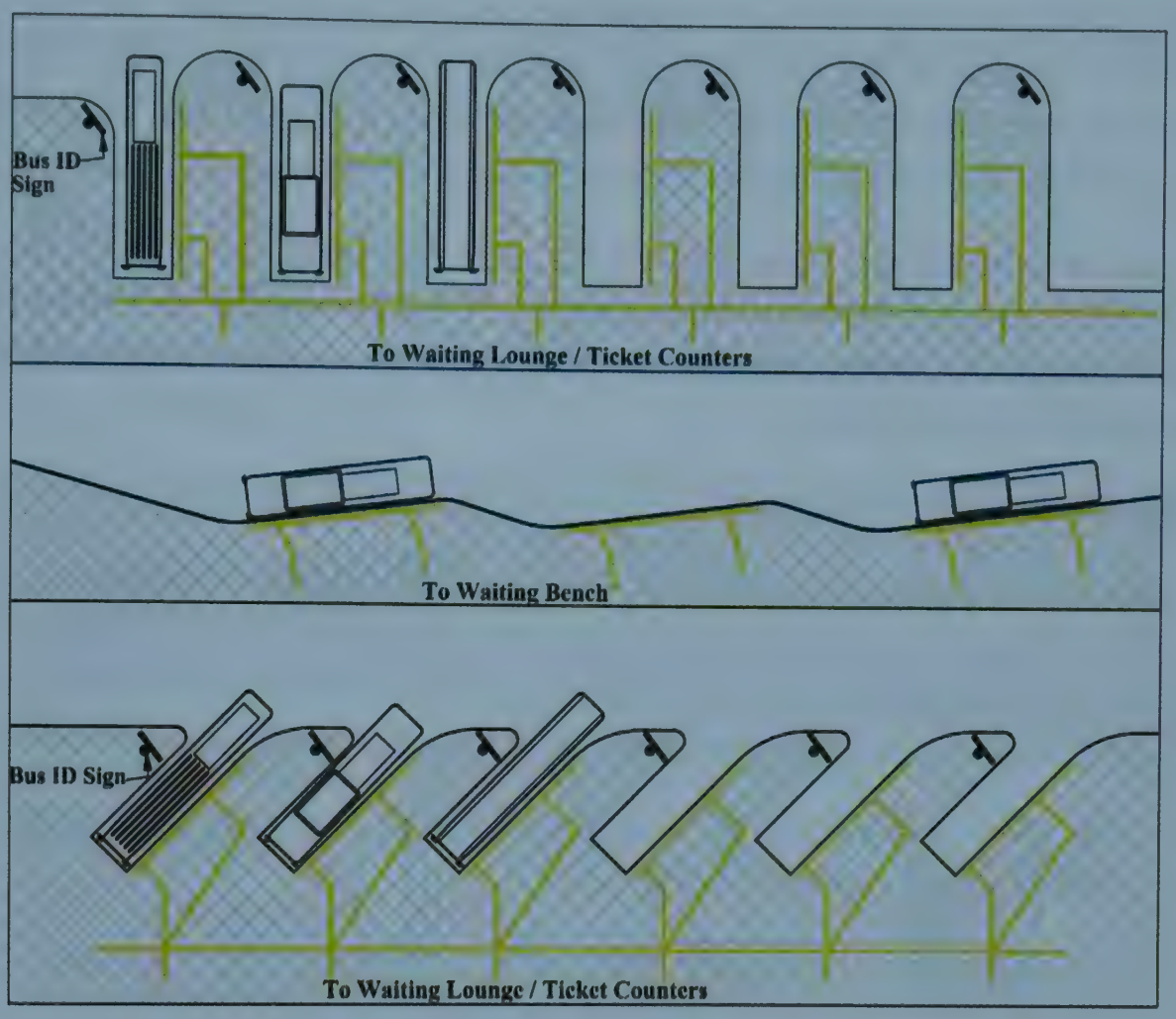


Fig. 5.12 Tactile Pavers

5.2.4 *Designing for the Mobility Impaired*

- Every access point should have provision for mobility impaired passengers.
- Dedicated drop-off and pick-up points are to be provided for wheelchair-bound passengers.
- The internal layout of the shelter should be barrier free to facilitate easy circulation.
- For any level change, there should be access via ramps or wheelchair friendly elevators.
- The space should be indicated inside and outside the elevator car using the universally recognized symbol for wheelchair accessibility.
- Appropriate safety grip should be installed for wheelchair users to hold onto. Ramps should preferably be of gradient 1:20 and never more than 1:12. Ramps should have a minimum width of 1200 mm for unidirectional movement and 1500 mm for bi-directional movement.
- At least one ticket booth in every group of booths should be at a suitable height for easy access by wheelchair users.

- Handicap accessible public toilets shall be provided in all public areas. Toilet rooms for the differently-abled shall be provided with an alarm linked to an outside light.

- The introduction of low floor buses, fitted with ramps for wheelchair access, has led to a requirement for appropriate curb side access at bus stops. In order for a bus to deploy its ramp safely, the ideal range of curb height is 125–140 millimetres, with 100 millimetres as the minimum. The size of the vertical gap between the curb and floor of the bus will affect the gradient of the ramp when it is deployed and so, it should not be steeper than 1:8 or 12%.

- A skilled manual wheelchair user should be able to complete a 360° turn in a space of 1500 mm x 1500 mm, so footway widths should be a minimum of 2 m but preferably 3 m. Also, boarding/alighting areas should be kept clear of all obstructions such as litter bins, telephone boxes and sign posts.

5.3 Travel Information and Signage

The travel information helps passengers in reaching the desired location in a bus port. Such information is to be provided mainly through signage. Signage is a critical design element for the proper functioning of a complex public transit facility. Every aspect of the end-user experience is streamlined and facilitated by signage and performs the following vital functions:

- Wayfinding – Guides passengers to and from various bus port area, particularly orienting them at the point of entry, exit and transfers.

- Information Dissemination – Provides essential information to facilitate navigation of the facility components and the transit systems services.

- Security – Contributes to an enabling user-friendly, safe and reassuring user experience. Also vital in guiding people to safety especially during emergencies.

5.3.1 *Placement and Language*

While placing a signage, it should always be located at decision points in lateral and vertical circulation paths within areas that have clear sight lines and free of visual obstruction. The signage should be perpendicular to the line of travel or sight. Certain signs should be repeated to reassure passengers that they are on the correct path. Publicity signs may be placed parallel to movement direction and never obstruct any bus port signage. Signage should be placed in established vertical datum lines or designated signage placement zones and to be integrated with other bus port elements.

All signage shall have pictorial representation along with trilingual information (English, Hindi and Local language). The graphic elements which organize and convey the sign informational content should follow established standards to generate cohesiveness. All exterior signs should maintain adequate size to be visible up to 150 metres away. The size of letters in the sign boards depicting major information shall not be less than 300 mm.

5.3.2 *Types of Signage and Contents*

Signage are either fixed or mobile and can depict directions, amenities or identification signs. Dynamic signage should be considered as a part of the integrated bus information system to provide real-time information **(see Fig. 5.13)**.

- Informational signage – Display information about the use or operation of a place or system (route details, route maps, schedule and timings, fare details, etc.).
- Wayfinding/Directional signage – Presents text paired with directional arrows, to guide people in finding their way.
- Amenities signage – Identifies a place, space, entity or object.
- Prohibitory signage – Warns against certain behaviour and include rules of conduct and limitations of public access areas.

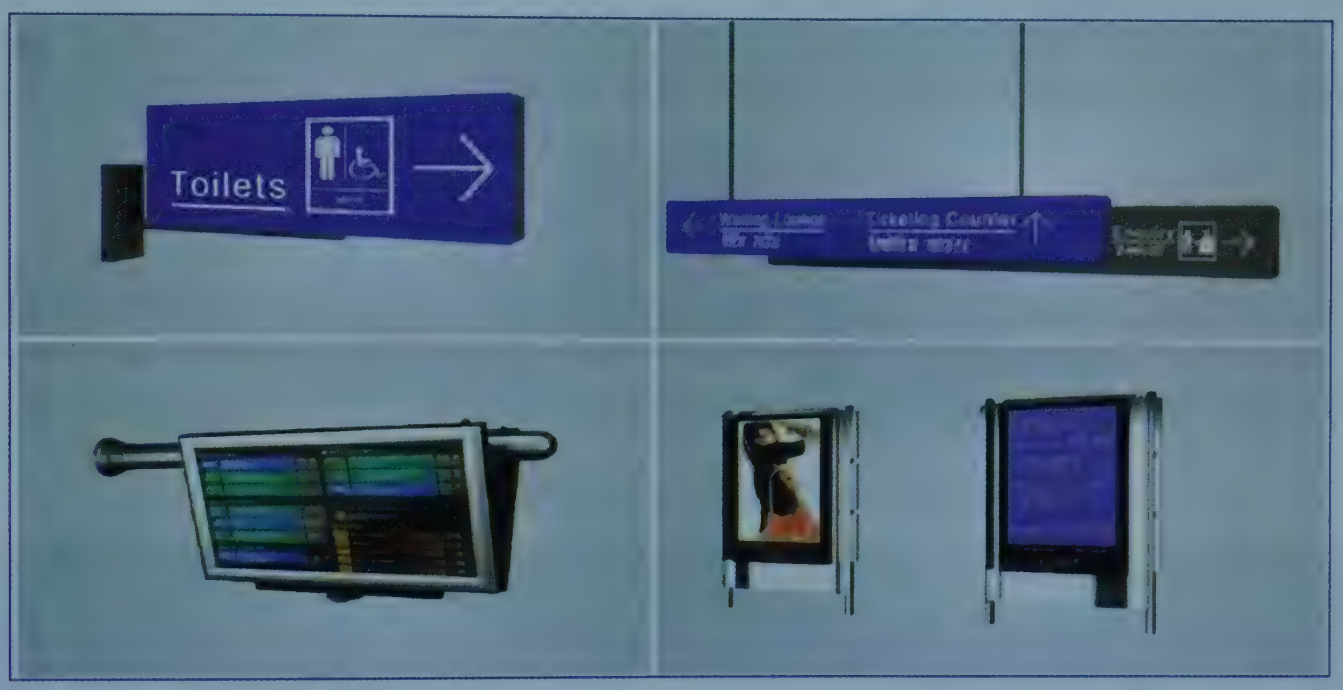


Fig. 5.13 Sample Signage

Passenger Information System (PIS) is meant for the passengers waiting at the bus port. The minimum information that the PIS system should disseminate is:

- Expected time of arrival and/or departure of a bus
- Number of buses running on a route
- Schedule of buses running on a specified route or coming to a bus stop
- Display of routes on a map

The PIS system should provide real-time data on schedules, timings, delays and other information (traffic, weather, etc.) in audio and/or visual format. The modes in which information can be disseminated are:

- Easily readable electronic board showing one or two routes, their ETA and destination bus bay in the one hour (configurable) on each bus bay
- Easily readable electronic board showing the buses expected to be on the boarding in the next few hours along with the bay number and timings

5.4 Safety and Security

To ensure a safe and secure environment in the bus port premises, certain measures should be implemented in the planning stage itself. The measures below are only indicative and should be reinforced based on site specific needs. Separation of the bus port building and the remaining site is necessary to determine security measures and protocols in case of threats/emergencies. It is also recommended a police booth and its own security agency with control room facility inside the Bus port.

5.4.1 *Electronic Surveillance*

To provide an efficient and effective surveillance of the bus port following security provisions are essential:

(i) CCTV System Design

Deployment of a CCTV system that meets the functional and operational requirements of the bus port is essential. Therefore, it is important to define the CCTV system requirements to fulfil the security needs of bus port. **Table 5.6** provides the CCTV system requirements.

Table 5.6 Defining CCTV System Requirements

Defining CCTV System Requirements	Defining CCTV System Design Considerations

• Need Assessment
  • Functional requirements
  • Operational requirements
  • Infrastructure requirements
  • Data storage requirements
• Multidisciplinary system design team.
• Site Analysis
• System layout considerations
	• Lighting
	• Robust and reliable power supply
	• Video transmission
	• Scalability
	• Cost
	• Reliability and Maintainability

The needs assessment gathers and analyses four sets of requirements:

- Functional requirements – Define camera coverage needs such as surveillance of perimeters, parking area, and storage areas; surveillance of approaches to, and spaces within, buildings or other structures
- Operational requirements – Define the capabilities of the CCTV system components to provide the expected information under all operating conditions (day and night operations, lighting, weather conditions, and temperature changes)

- Infrastructure requirements – Define needs for installing or accessing fibre or hard-wire cables, wireless networks, and power sources, necessary to successfully implement an integrated CCTV system
- Data storage requirements – Define the organization's video retention and storage

(ii) Cameras

Different types of cameras should be chosen based on the operational requirements. Fixed cameras, pan tilt and zoom (PTZ) cameras, day/night cameras and thermal imaging cameras are few types of cameras that can be helpful for operation.

(iii) CCTV Monitors

The selection of monitors is important to the quality of the image and the selection of these monitors should be based on the need and cost implications. The components of a CCTV system is given at **Fig. 5.14**.

Fig. 5.14 Components of a CCTV System

(iv) Digital Video Recorders (DVRs)

DVRs perform the complex task of digitizing, compressing the video feed from the CCTV cameras and storing the data for retrieval during the storage period. Since a bus port is a facility which typically runs in a 24x7 environment with high footfall and carries a constant threat perception, it is advisable to deploy a DVR appropriate to the needs.

5.4.2 *Safety Parameters*

Bus ports are open for extended hours and are likely to be perceived as unattended or unsupervised if adequate countermeasures are not taken. Utmost care should be taken in ensuring that passengers feel safe. The measures that can be taken to ensure safety are mentioned below:

(i) Minimizing Health Hazards

Each design decision should be carefully reviewed to reduce accidents and health hazards. The common prevention strategies would include adequate illumination levels, anti-skid surfaces, careful grading between levels, guards and safety rails at appropriate places etc.

(ii) Security Measures

The bus port perimeter should be definable and lockable in case of an emergency to minimise threat to build structures and equipment. Bus port access points should be equipped with CCTV camera, luggage scanning machine, body scan machines, security booths etc. A security control, response and monitoring room should be provided to control all surveillance, emergency communication systems, intrusion detection if applicable and any other security feature provided. Bus port should also be provided with a central emergency communications system. Adequate lighting, well designed and strategically located street furniture, activity generators like shops, clear visibility also reinforce the perception of being safe.

(iii) Minimizing Fire Hazards

Appropriate fire and life safety codes of NFPA and NBC should be referred for each aspect of design. **Table 5.7** provides the Fire Fighting Measures.

Table 5.7 Fire Fighting Measures

SN	Particular	Less than 10 m More than 300 persons	Above 10 m but not exceeding 15 m	Above 15 m but not exceeding 24 m
1	Fire Extinguisher	✓	✓	✓
2	First aid hose reel	✓	✓	✓
3	Wet riser	×	✓	✓
4	Down comer	✓	×	×
5	Yard hydrant	×	×	✓
6	Automatic sprinkler system	only in basement	only in basement	✓

SN	Particular	Less than 10 m More than 300 persons	Above 10 m but not exceeding 15 m	Above 15 m but not exceeding 24 m
7	Manually operated electronically fire alarm system	✓	✓	✓
8	Automatic detection and alarm system	×	✓	✓
9	Underground static storage tank	×	100 000	150 000
10	Terrace tank	25 000 (5 000)	5 000 (5 000)	10 000
11	Pump near undergroundtank	×	2280 lpm Diesel and electric + 180 lpm jockey	2280 lpm Diesel and electric + 180 lpm jockey
12	Pump at terrace tank	900 (450)	450 (450)	×

5.4.3 *Lighting and Illumination*

It is vital to provide adequate lighting to promote a sense of real and perceived security as well as it should be in tune with other architectural elements of the bus port. Key considerations while designing an illumination plan would be:

- Safety
- Economy
- Durability
- Energy Efficiency
- Easy Maintenance

(i) Illumination Levels

The power requirement towards lighting load shall be calculated to meet the minimum illumination levels as required for operations in both indoor and outdoor operations. Indicative lux levels for operations inside and outside the Bus Port are as follows **(see Table 5.8)**:

Table 5.8 Recommended Illumination Levels for various Areas in the Bus Port

Area	Lux Levels
General	
Interactive Areas (task location)	200
Interactive Areas (background)	150
Signs, maps, displays	200
Site	
Open Parking Areas	50
Bus Port Entrance Areas	150
Bus Port Perimeter	50
Buildings	
Bus Platforms	100
Circulation Area	150
Waiting Area	150
Ticket Counter	300
Cloak Room	150
Cafeteria/Food Court	300
Guest Room	300
Record Room	150
Driver Lounge	150
Staff Dormitory	500
Offices	300
Toilets	100

(ii) Lighting System Fixture Parameters

The lighting system shall include normal lighting (powered via normal and reserve circuits) and emergency lighting (designated lights on emergency circuit) besides illuminated signage.

As an energy-efficient strategy, choice of luminaries should be monitored and intelligent systems should be introduced where lighting is activated by occupancy sensors. Of critical importance is increasing the dependence on natural light through careful fenestration design and material choice, offering potential energy savings. Natural light also increases the quality of indoor environment making it more identifiable and comfortable.

6. DESIGN TYPOLOGIES

6.1 Basic Design Grid and Anthropometric Planning Module

The grid system is developed on the basis of the most basic anthropometric module; i.e. that of a human being with two items of luggage **(see Fig. 6.1)**. Being a transit port, travel conditions are factored in the modules to fix the basis for space standards. The basic modules developed are discussed hereunder:

Passenger Standing – This module is based on a passenger carrying luggage and forms the basis for development of all other modules. All spaces are a function of the 900 mm x 900 mm grid.

Passenger Sitting – This module has been developed to be used in the waiting areas of the bus port. This unit uses a module of 600 mm x 1200 mm multiples

Ticketing – The base unit here is of the sitting module but is developed with the addition of a counter for serving passengers and a basic workstation for printing and issuing tickets. Each module is sized at 1800 mm x 1200 mm.

Staff Workstations – It is fully functional workstation designed within the expanded 1200 mm x 1200 mm module.

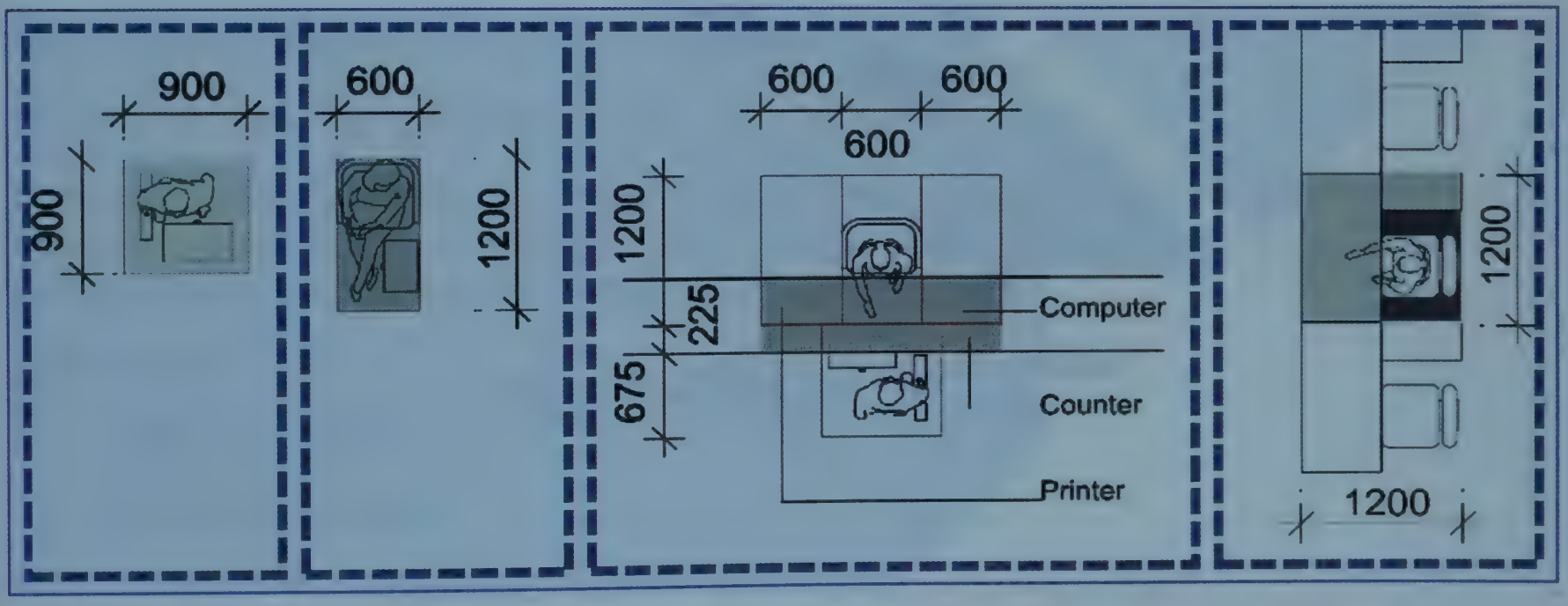


Fig. 6.1 Anthropometric Modules: Passenger Standing, Sitting, Ticketing and Staff Workstation

Basic Planning Module – The grid system was developed on the basis of a flexible 900 mm X 900 mm dimensions for ease of replicability, expansion and adjust position of different modules arising from the same basic grid **(see Fig. 6.2)**.

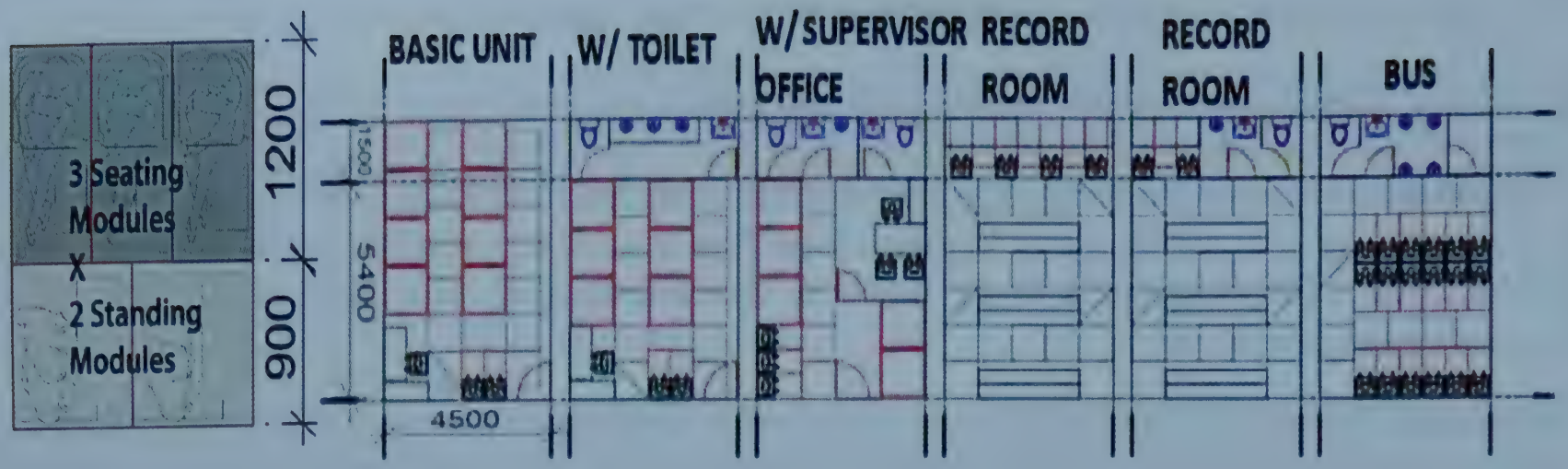


Fig. 6.2 Basic Planning Module with Variations in Office Module

The principles of adjacency and addition have been applied to vertical integration and expansion given in **Fig. 6.3**.

Fig. 6.3 Additive Modules for Vertical Expansion

As discussed, the smallest bus port is one with 10 bays. Hence, a 10 bay bus port is used as the basic planning module and can be expanded to required bus port size of any multiple of 10 bus bays. Given the basic assumption for a 10 bay module, it was found that a 10 bus bay module may be adopted for the purposes of internal allocation of space within the typical bus port building, with each subsequent space displaying a relationship to the whole.

The following **Fig. 6.4** will show the possible layouts for individual spaces along with their different configurations and modules using these assumptions.

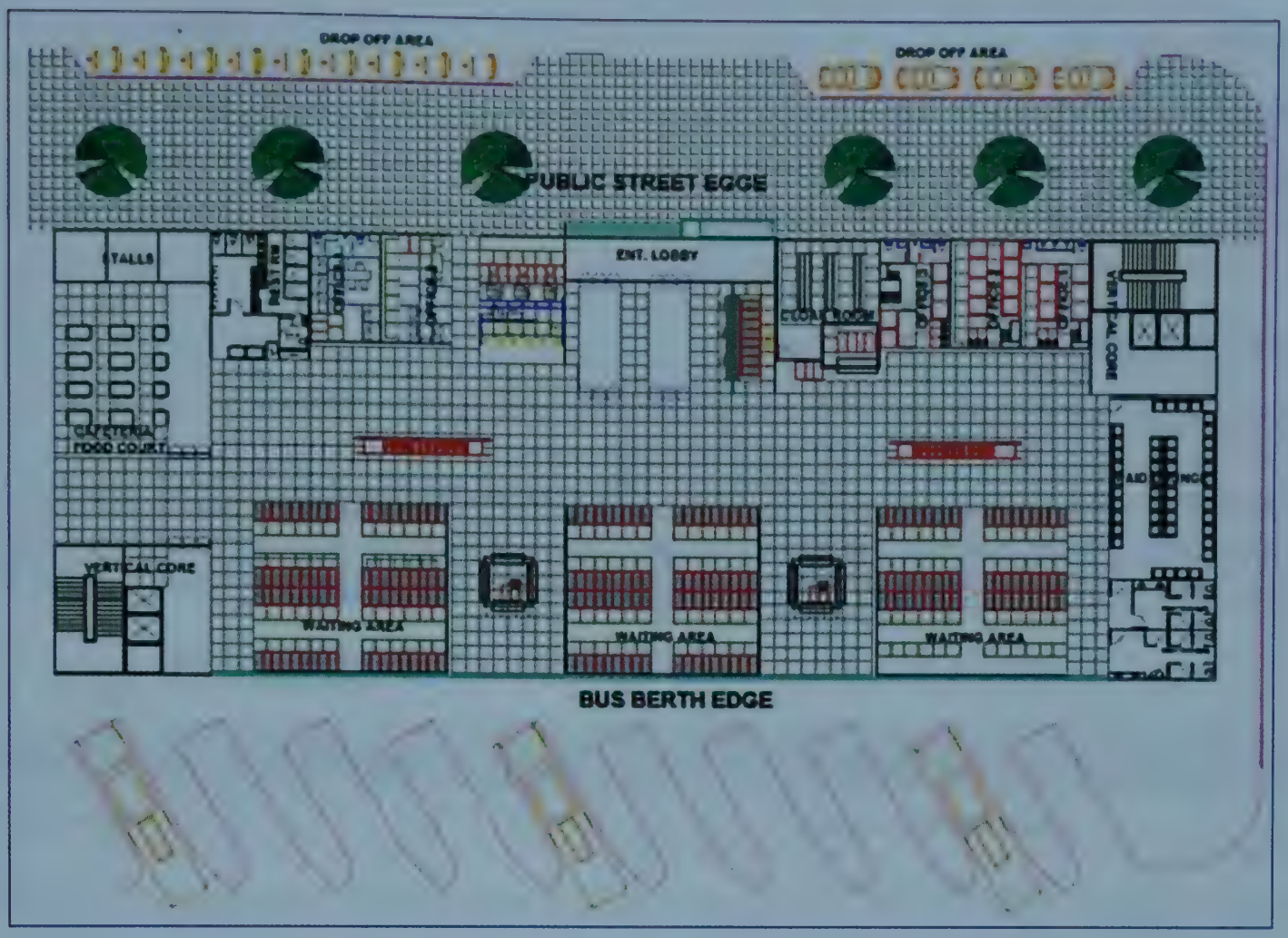


Fig. 6.4 Combined Module Serving 10 Bus Bays

6.2 Space Standard and Functional Modules

6.2.1 *Architectural Space Standards*

Using the above mentioned modules, the space standards for different segments of port can be designed efficiently. These standards can be used to design various necessary locations for the passengers, bus port staff and bus staff which includes:

Passengers

(i) Entrance Lobby

(ii) Ticketing Counters

(ii) Cloak Room

(iv) Waiting Areas

(v) Cafeteria/Food Court

(vi) Guest Room

(vii) Passenger Lounge

(viii) Restroom

Bus Port Staff

(i) Office

(ii) Record Room

Bus Staff

(i) Staff Dormitory and Driver's Lounge

6.2.2 *Components of Bus Port*

The smallest bus port is the one with 10 bays. Hence, a 10-bay bus port is used as the basic planning module and can be expanded to required bus port size of any multiple of 10 bus bays. A typical bus port with a 10-bus bay design may have the following components **(see Table 6.1)**:

Table 6.1 Bus Port Components for 10 Bus Bay Port

Sr.No.	Bus Port Facility	No. of Components	Preferred Location
1	Concourse Area	1	Ground floor
2	Entrance Lobby	1	Ground floor
3	Ticketing Counters	1	Ground floor
4	Cloak Room	1	Ground floor
5	Waiting Area	3	Ground floor
6	Cafeteria/Food Court	1	Ground floor
7	Passenger Lounge	1	Ground floor
8	Restroom	1	Ground floor
9	Office	5	Ground floor
10	Guest Room	1	First floor
11	Record Room	1	First floor
12	Staff Dormitory & Driver's Lounge	2	First floor

6.2.3 *Passenger Movement Area*

It is the area required for movement of passengers inside the bus port which is a function of desired walking speeds and ability to bypass slower moving pedestrians, cross a pedestrian traffic stream or to walk in the reverse direction of a major pedestrian flow. The passenger should be able to negotiate its route having no or minimum conflicts with other pedestrians or changes in walking speed. Pedestrian performance should be typically defined for the busiest 15-min period of the bus port. For the purpose, the area can be calculated based on the desired level of service.

6.3 Level of Service

The success of a bus port facility design would not only be measured by effective bus operations but also by taking into account both qualitative and quantitative factors affecting the pedestrian movement. For this purpose, level of service plays an important role by taking into account the pedestrian movement while designing the bus port facility.

The objective of LOS standards is to maintain a desirable pedestrian area and flow rate throughout the facility. LOS determines the performance standards to provide a method of sizing passenger circulation elements in a bus port facility i.e. platforms, walkways, doorways, stairs and escalators. The effect on LOS standards needs to be carefully considered wherever space is a constraint. The calculation of area for different passenger circulation elements is discussed below.

6.3.1 *Size of Bus Port Platform*

It is based on maintaining the desired pedestrian LOS **(see Table 6.2)** in the waiting and circulation areas with provision of space for stairs and escalators wherever required.

Platform Area = Required waiting area + Walkway area + Queue area + Buffer zone area

To calculate the desired bus port platform size, following steps shall be undertaken:

(i) Choose the average pedestrian space based on the desired LOS

(ii) Adjust for passenger characteristics (passengers with bags) if required (Assume 25%)

(iii) Estimate the maximum passenger demand at a given time in a peak period of 15 minutes

(iv) Calculate required waiting space (Average pedestrian space x Maximum passenger demand)

(v) Calculate additional walkway width with desired LOS

(vi) Calculate queue space for stairs and escalators wherever required for exit points with desired LOS

(vii) Add a buffer zone of 0.5 m on each side to the width of the platform

(viii) Total platform area (Required waiting space + Walkway width + Queue space + Buffer zone)

Table 6.2 Levels of Service

LOS	Waiting Areas		Walkways & Doorways		Stairways		Description
	Pedestrian Space (m^2/p)	Inter-person Space (m)	Pedestrian Space (m^2/p)	Flow per Unit width (p/m/min)	Pedestrian Space (m^2/p)	Flow per Unit width (p/m/min)	
A	≥ 1.2	≥ 1.2	≥ 3.3	0 – 23	≥ 1.9	≤ 16	Sufficient area to freely select speed and to pass slower-moving pedestrians. Reverse flows cause limited conflicts.
B	0.9 – 1.2	1.1 – 1.2	2.3 – 3.3	23 – 33	1.4 – 1.9	16 – 23	Sufficient area to freely select speed with some difficulty in passing slower-moving pedestrians. Reverse flows cause minor conflicts.
C	0.7 – 0.9	0.9 – 1.1	1.4 – 2.3	33 – 49	0.9 – 1.4	23 - 33	Speeds slightly restricted due to inability to pass slower-moving pedestrians. Reverse flows cause some conflicts.
D	0.3 – 0.7	0.6 – 0.9	0.9 – 1.4	49 – 66	0.7 – 0.9	33 – 43	Speeds restricted due to inability to pass slower-moving pedestrians. Reverse flows cause significant conflicts.
E	0.2 – 0.3	< 0.6	0.5 – 0.9	66 – 82	0.4 – 0.7	43 – 56	Speeds of all pedestrians reduced. Intermittent stoppages likely to occur. Reverse flows cause serious conflicts.
F	< 0.2	Variable	< 0.5	Variable	≤ 0.4	Variable	Complete breakdown in pedestrian flow with many stoppages. Forward progress dependent on slowest moving pedestrians.

6.3.2 *Walkway and Doorway Width*

The minimum walkway or doorway width of 2 m shall be provided.

Walkway/ Doorway width (m) = Pedestrian demand per minute/(Maximum pedestrian flow rate based on desired LOS x Adjusted Ratio due to passenger characteristics)

6.3.3 *Stairway Width and Stair Queuing Area*

Table 6.3 provides Calculations for Stairway Width and Queuing Area.

Table 6.3 Calculations for Stairway Width and Queuing Area

Stairway width (m) =	(Pedestrian demand per minute/(Maximum pedestrian flow rate based on desired LOS x Adjusted Ratio due to passenger characteristics)) + 0.75 Note: • Minimum stairway width of 2 m shall be provided. • Maximum Riser height shall be 0.15 m.
Stairway Capacity (p/h) =	Stairway width x Maximum pedestrian flow rate based on desired LOS x 60
Stair Queuing Area (m^2) =	(Maximum Demand per hour – Stairway Capacity) x 0.5

6.3.4 *Number of Escalators and Escalator Queuing Area*

The nominal capacity values for escalators are given in **Table 6.4**:

Table 6.4 Escalator Capacity

Type Width at Tread (m)		Incline Speed (m/min)	Nominal Capacity (p/min)
Single width	0.6	27.4	34
		36.6	45
Double width	1.0	27.4	72
		30.5	85
		36.6	90

6.4 IPT and Private Parking

Bus port is accessed by the users by various modes. While private modes need parking and drop off areas, IPT and NMT also need spaces for pickup/drop in bus port area for efficient multimodal integration.

6.4.1 *General Consideration*

Various options would be explored for the entry/exit combination to the parking lots keeping in mind the adjacent site access. Appropriate consideration shall be given to cater to the needs

of all traffic movements at the bus port. The design plans shall be developed keeping in view the zoning of different activities in the bus port development. Primary design considerations for parking lots should include:

- Parking facilities should be provided for all vehicle category keeping in view the requirement of parking for differently abled people.
- The parking access to and from the bus port should be designed in a manner that it causes least conflicts with the bus flow.
- The design of walking/road crossing facilities should be of universal accessibility for parking users.
- The walking distance from parking lot to the bus port and vice-versa should be within 200 m.

6.4.2 *IPT Parking*

The different types of Intermediate para transit commonly in operation in India are - 3 passenger auto rickshaws, Vikrams/6 passenger auto rickshaws and mini buses/tempo travellers. The 3 and 6 passenger auto rickshaws are typically about 1.3 m wide, 2.6 to 2.8 m long and 1.8 m high with a turning radius of 2.9 m.

IPT parking should always be given priority after pedestrian and public transit modes. This means that every bus port site should provide a designated area for these modes to drop off and pick up passengers.

The principle to be considered in designing the area for IPTs is that the IPT drivers want to be as close to the passengers exiting from the bus port as possible. This means that double row configurations where IPTs wait in two rows is not a practical option. The best practice is to give a curbside location to each auto rickshaw or IPT mode so that the passenger or passengers can directly alight or board from the curb. In case of auto rickshaw or shared auto area, an empty lane with enough room for an auto rickshaw to pass by one which is waiting should be given.

6.4.3 *Bicycle Parking*

Bicycle stands, pbs and charging facilities are typically integrated into exterior spaces instead of providing large dedicated areas of parking. This is done so as to provide preference for the bicyclist in terms of access to the bus port. Different kinds of mounting are used for bicycle stands i.e. in-ground mounting, surface mounting, rail mounting and wall mounting.

6.4.4 *Private Vehicles Turning, Drop-offs and Parking*

Even though the private vehicle is the lowest on the list of hierarchy of transit modes, they should be accounted for in terms of drop off and parking. The following **Fig. 6.5** express various dimensions involving both passenger cars and motorcycles. Turning radii at intersections should be 4 m on local and collector streets, and maximum 9 m on arterial and sub-arterial streets (IRC:103).

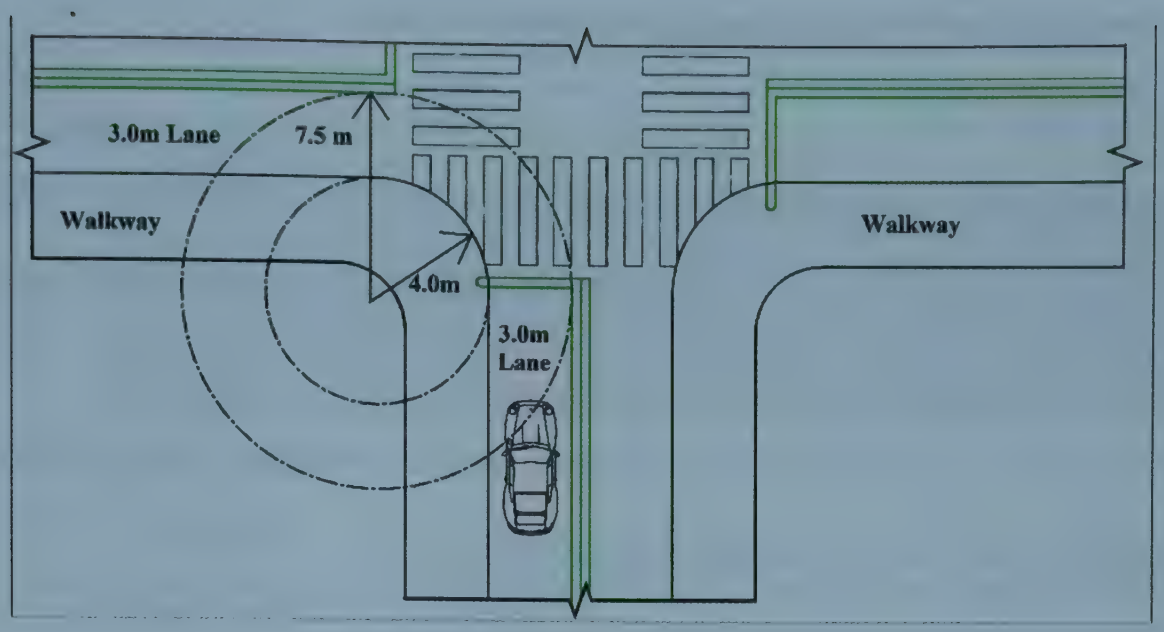


Fig. 6.5 Vehicle Turning, Drop-Offs and Parking

6.5 Typologies

6.5.1 *Parametric System for Development of Layout Options*

Before determining the design of the bus port building and the respective layout configurations, certain criteria are laid down on a macro level to ascertain "scenarios" for development. These criteria include a number of aspects such as turnaround time, number of long term an short term stoppages, bus network (both intra-city and inter-state), geographical context, etc. which are mostly assessed at the level of the City Mobility Plan for each city. However, there are additional criteria which directly affect the design for each bus port type which are discussed in **Fig. 6.6**.

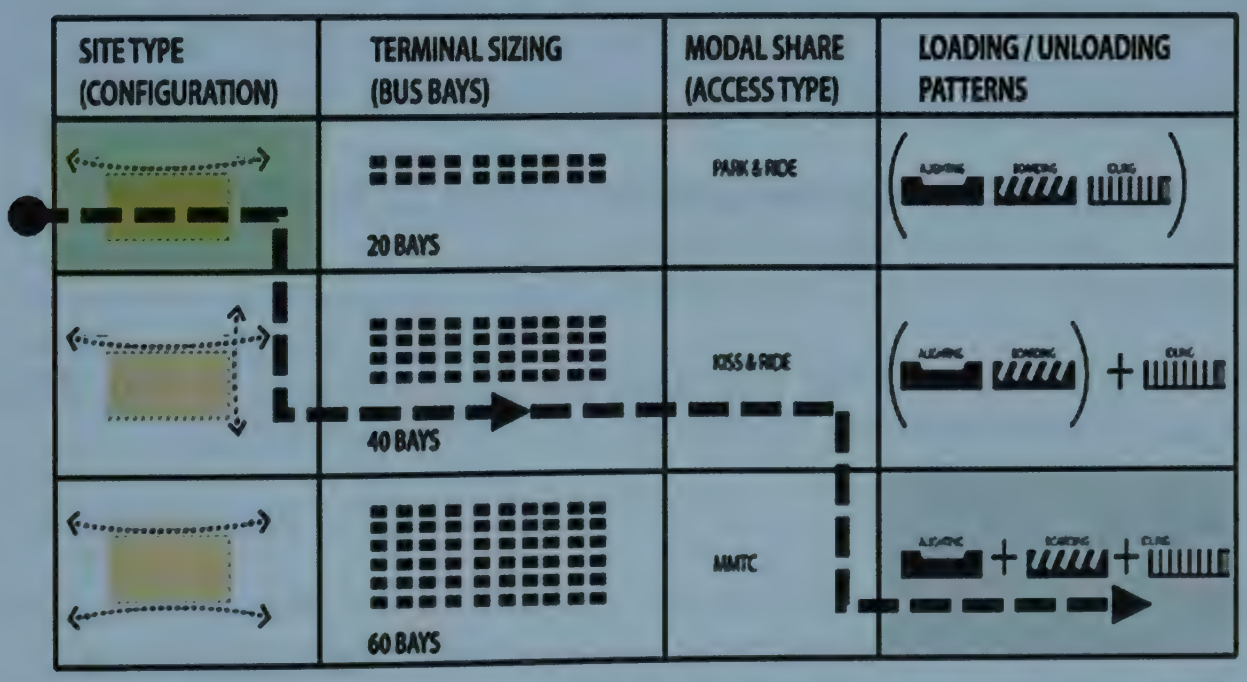


Fig. 6.6 Parametric System for Development of Layout Options

While theoretically each criteria/parameter will help generate a different option/permutation, certain criteria will be incompatible with others, thus generating a limited number of recommended layout types.

The following pages will demonstrate two such layout types.

6.5.2 *20 Bus Bay Layout Type*

This particular scenario as shown below envisages the following four parameters.

- The site has access thoroughfare only on one side with its longer side alongside it.
- Capacity of twenty bus bays
- access and egress modal share characteristic that is primarily park and ride and
- Boarding, alighting and idling happens together.

(i) Site Dimension

Fig. 6.7 provides Site Dimensions for Sample 20 Bay Bus Port.

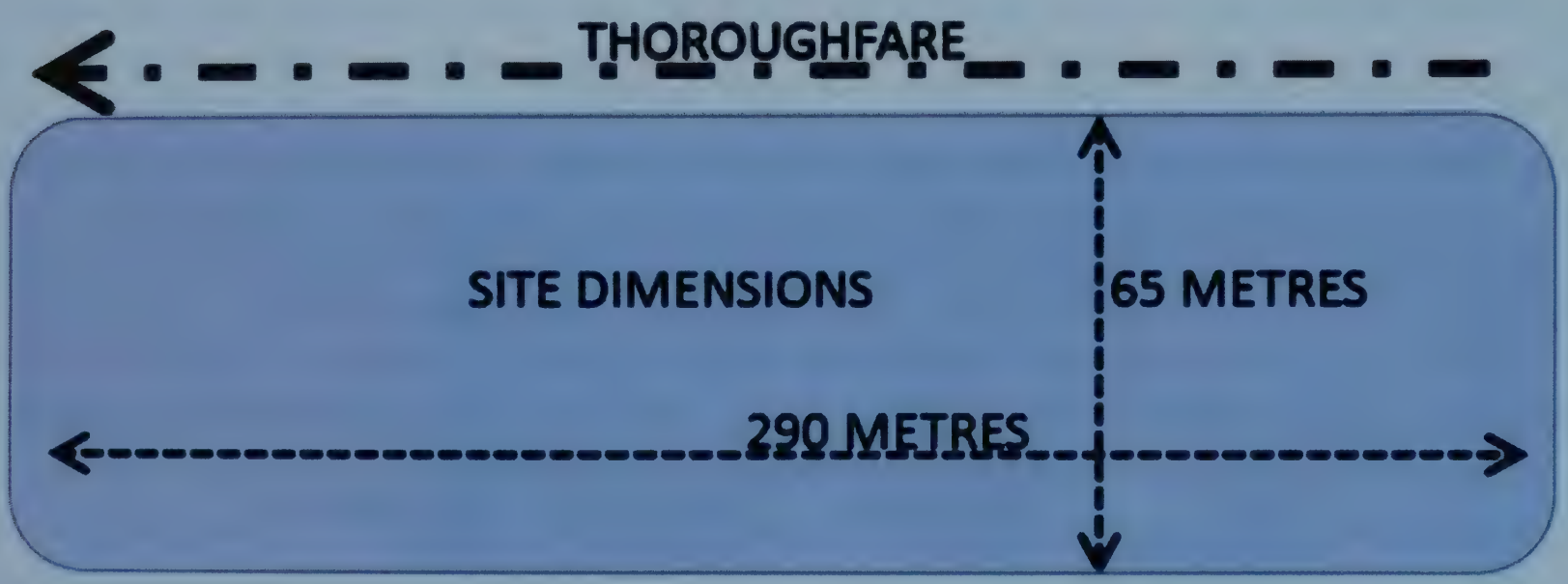


Fig. 6.7 Site Dimensions for Sample 20 Bay Bus Port

(ii) Major Components

This twenty-bay bus port scenario has four major planning components. **Fig. 6.8** represents the Zoning for Sample 20 Bus Bay Port.

- Bus port building
- Bus bays;
- Car parking that makes it a park and ride facility
- Drop off zone that receives passengers who reach by all other modes such as local city buses, automobiles, intermediate para transit or non-motorized transit modes.
- It must be noted here that in this case, the street edge is utilized as a drop off zone.

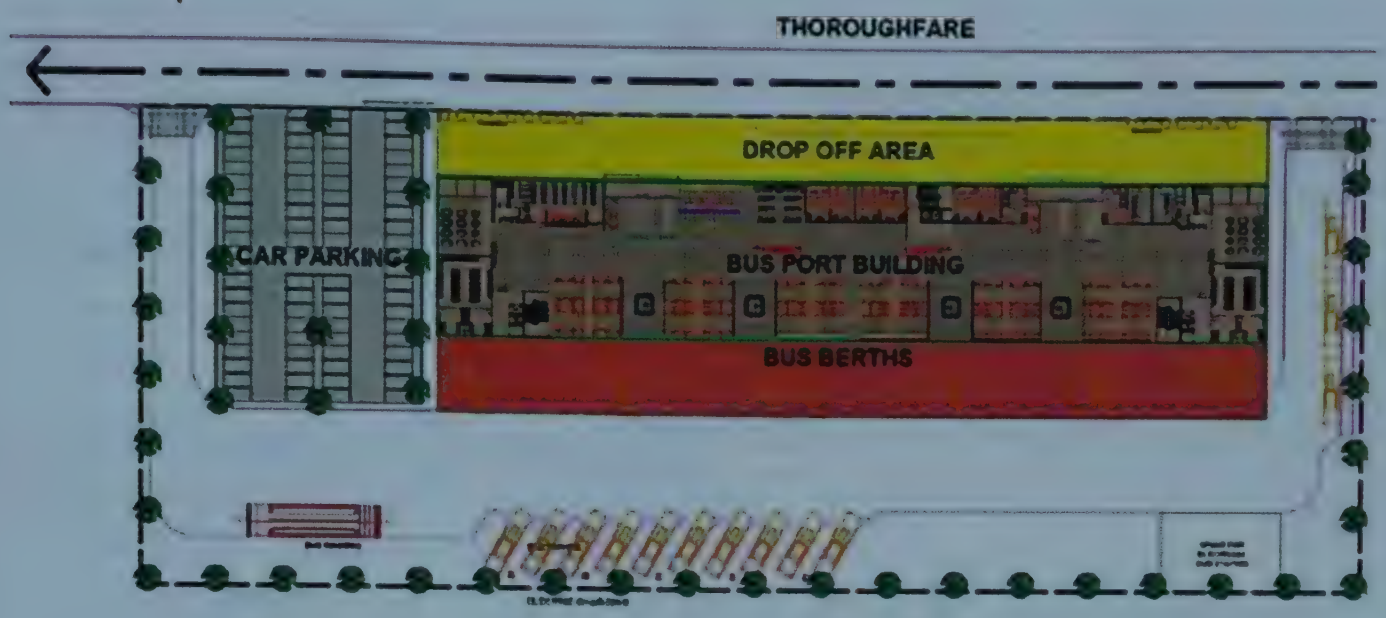


Fig. 6.8 Zoning for Sample 20 Bus Bay Port

(iii) Movement

Movement has been planned according to site planning principles such as one way bus movement for easy maneuverability, minimum conflict points between modes, preference for non-motorized and intermediate para transit modes, tabletops for pedestrian crossing **(see Fig. 6.9)**.

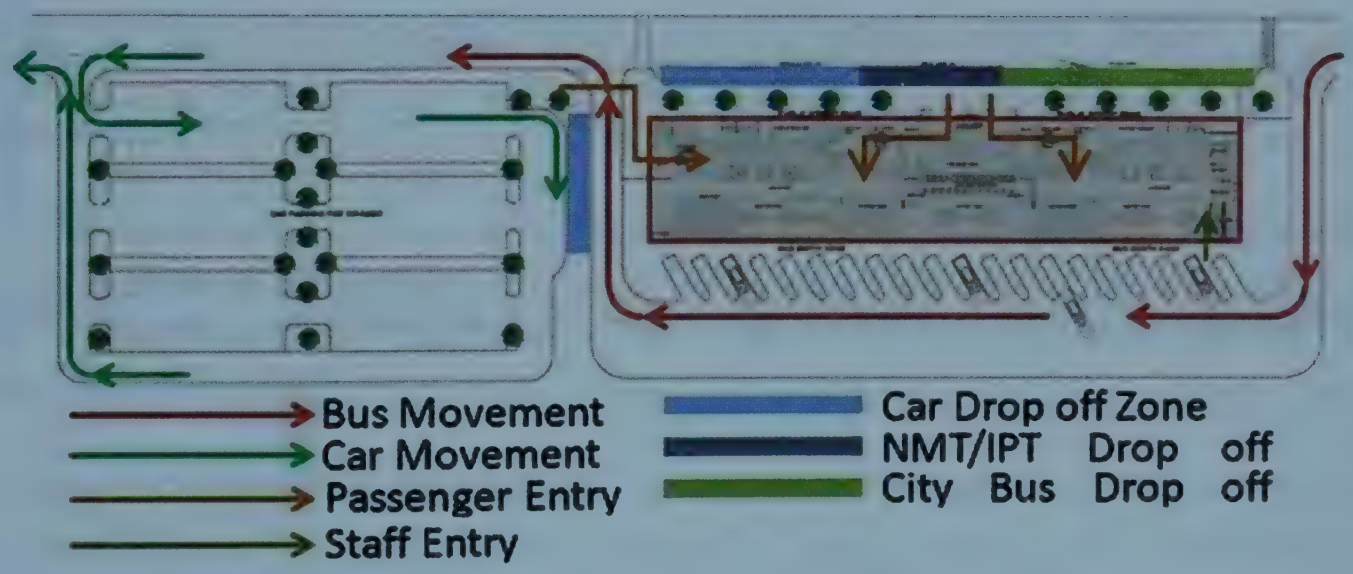


Fig. 6.9 Movement for Sample 20 Bus Bay Port

(iv) Bus Port Detailed Layout

The detailed layout demonstrates how a twenty bus bay port can be planned using the planning module of ten buses and the basic functional/programmatic blocks developed.

It is to be noted here that the street edge of the bus port building is developed as an active public space and could comprise of retail or office built uses. It is assumed that a park and ride facility such as this one will tend to be in a suburban location and this is the reason why this bus port layout attempts to create an active public edge on the street. **Fig. 6.10** represents the Layout for Sample 20 Bus Bay Port.

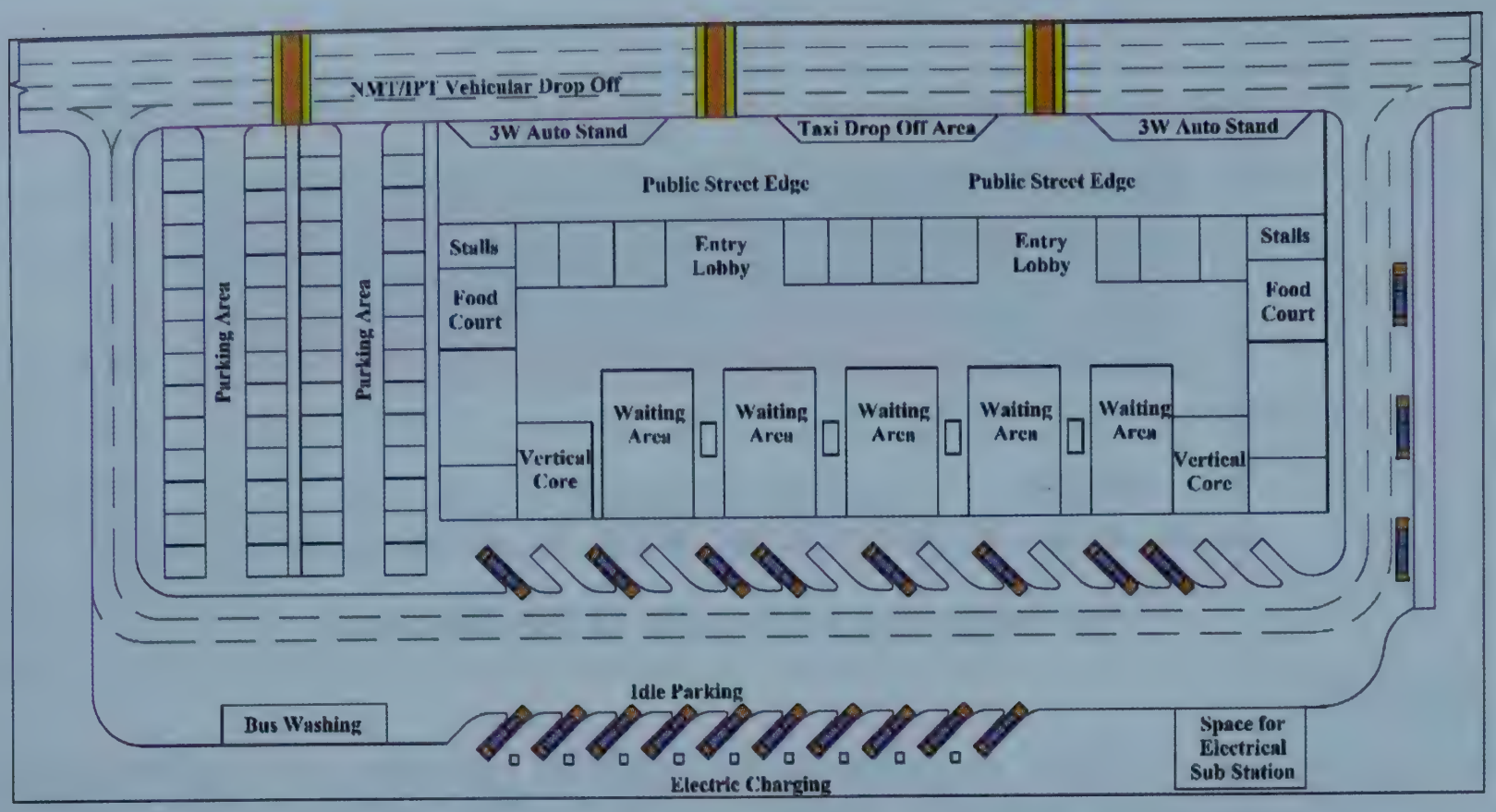


Fig. 6.10 Layout for Sample 20 Bus Bay Port

6.5.3 *40 Bus Bay Layout Type*

This particular scenario as shown below envisages four specific parameters

- The site has access thoroughfare on two sides.
- Capacity of forty bus bays
- Access and egress modal share characteristic that is primarily park and ride and
- Boarding, alighting and idling happens together.

The detailed layout demonstrates how a forty bay bus port with a primarily kiss and ride modal share can be planned. This bus port layout pays special emphasis on the additional roles a large facility like this is likely to take on, like increased number of bus port staff and possibility of more administrative functions. Further a hotel/rest house has also been planned with a separate entry. The hotel/rest house and administrative functions are planned to extend to the first floor.

6.6 Traffic Circulation Planning at Bus Ports

Traffic circulation movement including Bus, Car, IP and Passenger movement has been planned according to site planning principles. This movement includes one-way bus movement for easy maneuverability, minimum conflict points between modes, preference for non-motorized and intermediate para transit modes. **Fig. 6.11** provides Traffic Circulation Planning at Entry and Exit of the Bus Ports.

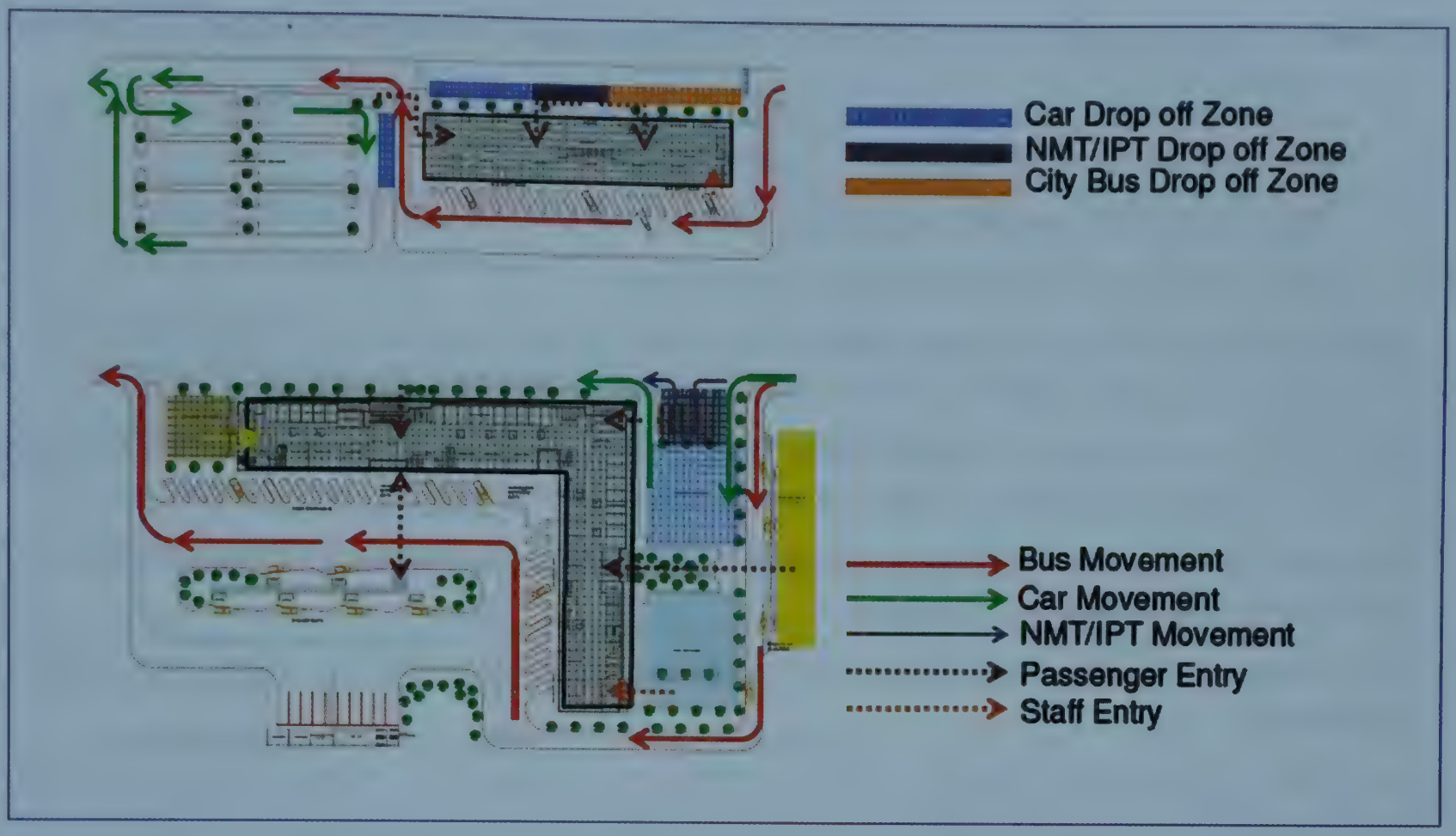


Fig. 6.11 Traffic Circulation Planning at Entry and Exit of the Bus Ports

7. OPERATIONS AND MAINTENANCE GUIDELINES

7.1 Introduction

The bus port facility or any other facility requires proper maintenance to upkeep the facility to the desired level of service/standard. Proper maintenance increases the lifespan of a facility by reducing the normal wear and tear caused by operations and environment. The objectives of effective operation and maintenance are:

- To keep the facilities to the desired level of service/standard
- To reduce deterioration, wear and tear in the machinery, building

This chapter provides maintenance procedures/standards for the various components of the bus port including passenger amenities to operate and maintain the bus port facility effectively and efficiently.

7.2 Objectives

The inclusion of the following goals/objectives would help a bus port facility operator formulate a successful operation and maintenance strategy:

- Perform maintenance on a routine and periodic basis. Provide and operate functional facilities that
    - Meet the bus port desired level of service/standard;
    - Have an environmentally acceptable atmosphere for users of the facility; and
    - Ensure the safety of staff and the passengers.
- Identify potential problems early within the context of the planned maintenance system so that corrective action may be planned and completed in a timely manner.
- Establish a maintenance list for planned operation of utilities and maintenance thereof. Follow an orderly program so that maximum operational efficiency is enhanced.
- Conserve energy and resources by ensuring maximum operating efficiency of energy-consuming equipment and systems.
- The users of the bus port are to be provided well-maintained facilities and adequate information.
- Identify and implement possible improvements that will result in more efficient operation.
- Establish data collection systems to develop: uniform reporting formats
- Use of electronic data processing
- Supervisory and management control reports
- Continual feedback of information between departments through communications and manuals
- Institute systems for reporting historical data and operating statistics

Usage of Green roofs and provision of solar, rain water harvesting, nature based bio swales can be helpful in achieving the sustainability.

7.3 Broad Scope of Work

The services to be provided by the operator of the bus port would include all activities, needed to be carried out in order to comply with the service quality levels and other performance criteria indicated prescribed internally by the operator or through an agreement such as Concession Agreement.

7.3.1 *Maintenance of Bus Port*

This includes routine and periodic maintenance activities for the bus port excluding the areas which are under the control of third party. The routine maintenance will include maintenance of bus and passenger circulation area, bus port building, passenger concourse areas, passenger amenities, parking areas, pavement condition, water supply, drainage and sewerage, solid waste facility, other ancillary building services, mechanical equipment etc. The periodic maintenance shall include maintenance at regular identified intervals for the various bus port components.

The various facilities to be maintained by the operator of bus port include the following:

(i) Key Bus Port Facilities

The following key bus port facilities proposed in the bus port are:

- Bus Bays for Boarding & Alighting
- Idle Parking Bays
- Bus Circulation Area & Approach Roads
- Ticketing Counters, Enquiry Counters, Reservation Office
- Tourist Information Centres
- Authority administration requirements like Traffic Controller's office
- Operator of bus port's Office
- Entry & Exit to the bus port Component
- Passenger Entry & Exit to the bus port Component
- Interconnecting Subways & Pathways, Ramps between various components, if applicable.
- Management Information System including public address system
- Toilets for staff
- Store Room
- Security Guard Cabins

(ii) Passenger Amenities

- The following key passenger amenities proposed in the bus port are:
- Passenger Concourse Area for Boarding & Alighting
- Passenger Platform for Alighting & Boarding
- Public Utilities (Toilets, Drinking Water Chambers etc.)
- Waiting Halls
- Cloak Room & Parcel Room
- Seating Arrangements, Information Signage's, Display Boards
- Commercial Facilities for the bus port Facilities like kiosks, canteen, general store etc.

Parking Area for private vehicles (two wheelers and cars) and intermediate public transport like auto rickshaws, taxis along with their approaches, entry and exit, drop-in and drop-off areas, pick-up zones.

Bill-boards and Hoardings for advertisement

(iii) Common Areas & Facilities

The following major supporting infrastructure requirements proposed in the bus port are:

- Water Supply and Sanitation Structures
- Storm Water Drainage
- Rain Water Harvesting Structures (d) Solid Waste Management Systems (e) Communication Systems
- Landscaped Area
- Electric Sub-Station
- Lifts & Escalators
- External & internal Lighting system
- Service lanes for modal transfer from other public and private modes of transport to the bus port

7.3.2 *Operations Management*

The operations management is related to the bus port facilities. This includes the following bus port operations:

- Management of inflow and outflow of buses;
- Allocation of bays in the bus port including idle parking of buses;
- Streamlining of traffic flows and circulation pattern;
- Functioning of passenger and crew amenities;
- Collection of lease rentals and other user charges;
- Information and communication systems including public address system;
- Other bus port operations include functioning of break down services, providing emergency response system, regular security and scheduled inspections; Undertaking traffic management measures in internal circulation during routine and periodic maintenance activities.
- Implementing the Management Information System (MIS) that would help in monitoring of the operation and maintenance activities in the bus port.

7.4 Allowable Activities in a Bus Port

7.4.1 *Passenger Amenities*

These passenger amenities which are a part of the bus port shall be in compliance with The Road Transport Corporation Act, 1950 and other Applicable Laws.

The range of passenger amenities within the bus port is as follows:

Snacks Stall Tea/Coffee Stall Fruit/Juice Stall, Fast Food Outlet

Any activity not covered under the list shall require prior consent/approval from the concerned authority. Any commercial establishment or vendor, selling objectionable items, as notified by concerned authority or State Government either presently or in the future should not be allotted any space or allowed to enter the premises of the bus port.

The operator of bus port would ensure, by either planned allocation of space or control that any activity generated by commercial establishments, if any, should not hamper the bus port operations or people's movement in the passenger concourse area. The passenger amenities shall be well dispersed at appropriate locations in the bus port area.

7.5 Maintenance Standards

The operator of bus port shall perform routine and periodic maintenance activities for bus port facilities viz. civil, mechanical and electrical works and equipment, furniture and fixtures for meeting the laid performance standards. For the carried out maintenance works, the operator of bus port shall maintain records and submit reports, if required as described in subsequent sub-sections. The operator of bus port shall utilize as far as possible mechanized equipment and methods to perform these obligations. The operator of bus port should use all possible and updated technology in sanitation, solid waste management and disposal and rainwater harvesting for better upkeep and maintaining the best hygienic conditions in the bus port.

The operator of bus port shall maintain the bus port in traffic-worthy and passenger worthy condition and the bus port facilities in usable condition through regular maintenance and preventive maintenance of the various items and elements of the bus port.

7.5.1 *Routine Maintenance Standards*

The maintenance of the bus circulation area, parking area and approach roads including services lanes, if any shall include the planned on-going works and activities required to ensure safety, repair, small defects and to maintain the pavement in the required condition. It also includes carrying out of unscheduled maintenance works occasioned by irregular events such as accidents, natural failures, abnormal weather and the like. The activities of management and maintenance of approach roads and bus circulation area in the bus port shall be carried out by the operator of bus port such that the buses are able to circulate at a certain level of comfort and safety to achieve the required service time at the bays. **Table 7.1** provides Maintenance Standards for the Bus Circulation, Parking and Approach Roads.

Table 7.1 Maintenance Standards - Bus Circulation, Parking and Approach Roads

Item	Service Quality Criteria	Time allowed for repairs or Tolerance permitted
Potholes	Maximum 5 numbers in the bus circulation area, parking area, approach roads and service lanes.	Potholes must be repaired within seven (7) days after their detection.
Patches	Patches (i) shall be square or rectangular, (ii) shall be in level with surrounding pavement, (iii) shall be made using materials with specifications same as those used for the surrounding pavement, and (iv) shall not have cracks wider than three (3) mm.	Non-complying patches must be repaired within seven (7) days after their detection.
Cracking in pavement	There shall not be cracks more than 3 mm wide. Maximum allowable cracking shall be 5.0% in the bus circulation area.	Cracks more than 3 mm wide must be sealed within seven (7) days after their detection.
Rutting	Rutting shall not be more than 20 mm. Measured on a 2m straight edge. Maximum allowable rutting shall be 1.0% in the bus circulation area.	Rutting above threshold value must be eliminated within fifteen (15) days.
Cleanliness of the pavement surface, road surface	The area must always be clean and free of soil, debris, trash, spill off Oil/ Lubricants, dead animals and other objects etc. There should not be any standing water on the pavement.	The area must be cleaned daily. Dirt, debris and obstacles must be removed: (a) Within four hours if they pose a danger to traffic safety (b) Within eight hours if they do not pose any danger to traffic safety.
Pavement Surface Drainage	No water logging or standing water.	Temporary restoration within one day and permanent restoration within seven days.
Traffic Signs, Road/Pavement Markings	These shall be legible, clean and visible at all times.	Any damages/wearing shall be repaired and rectified within three days. The damaged and missing signs shall be replaced within fifteen days.

Item	Service Quality Criteria	Time allowed for repairs or Tolerance permitted
Storm Water Drainage System	There should be no silting and lockage in drains. The drains shall be free of any obstacles, solid waste. The drainage appurtenances shall be without any cracks. There shall be no leakages from the pipes. Thorough inspection shall be done before and during the monsoon season.	Obstructions must be cleared within two days after detection. Damages must be repaired within seven days after detection by reconstructing to the adequate shape and size. De-silting operations should be done once in a month with minor repairs if needed. During Monsoon, any blocked vent ways shall be cleaned as soon as possible.
Natural and Mechanical Ventilation for multi storey/ basement parking	To meet the required ventilation level as specified	Any disruption to mechanical ventilation if provided shall be rectified within 24 hours. Arrangements for natural ventilation like skylits, ventilators, shafts etc shall be cleaned after every 5 days.
Exit Routes and Stairways	To keep all exit routes and stairways/ ramps clear of any obstruction. Provide Inverter/UPS based lighting.	Obstruction to exit routes/stairways/ ramps shall be cleared on regular basis and emergency illumination.
Damage/Breach to the Compound Wall	No Damage/Breach allowed	Any damage/breach to the boundary wall of the bus port shall be rectified within three (3) days after their detection.
Bus Stoppers	Without any damage	Any damage to the bus stoppers shall be rectified within 2 days.

Passenger Circulation & Concourse Area, Subways and Office Corridor Space maintenance shall include the entire house keeping activities requiring routine and periodic maintenance. Annual maintenance shall be done for all electrical and mechanical equipment and accessories like fans, lighting arrangements etc. in these areas. **Table 7.2** provides the Maintenance Standards for the Passenger Concourse, Subways and Corridor.

Table 7.2 Maintenance Standards - Passenger Concourse, Subways & Corridor

Item	Service Quality Criteria	Time allowed for repairs or Tolerance permitted
Passenger Platform and Concourse Area, Ramps for handicapped	The platform and concourse areas must always be clean and free of soil debris, trash and other objects. Flooring, skirting, dado tiles should not bear cracks or missing. Oily, greasy surface owing to any spillage shall be cleaned immediately. Use mechanical means like floor wipers, vacuum cleaners etc. for cleaning purposes	Soil debris, trash and other objects shall be removed within 2 hours. Damaged or missing tiles shall be replaced and repaired within three days. The platform shall be wiped after every six hours.
Toilets and Urinals	The floor, dado, skirting should be clean and intact without any stains. The toilet and urinal pots, washbasins, cisterns, mirrors, taps shall not be damaged. The exhausts shall work properly. There should not be accumulation of water or waste in the toilet blocks. Water supply shall be maintained for 24 hours. Use mechanical means like floor wipers, vacuum cleaners etc for cleaning purposes. A minimum of 95% toilets, bathrooms and urinals shall be functional. Routine maintenance for earthing systems and meters indicating overloading of electrical installations	These shall be cleaned after every four hours with disinfectants. Damaged toilet and urinal pots, washbasins, cisterns, mirrors, taps shall be replaced within seven days of detection. Non-functional Toilets, Urinals, bathrooms shall be demarked with suitable sign boards.
Waiting Halls (Deluxe and General), Dormitories, Rest Rooms	These shall be maintained neat and clean by use of mechanical means like floor wipers, vacuum cleaners etc. The artificial ventilation sources like exhausts, fans, blowers shall function properly.	The floor shall be wiped every four hours. Toilet blocks are to be cleaned after every four hours. There shall be a regular appointment of an attendee in the deluxe A.C. waiting hall
Walls	No stains, splits, weathered paint to be left exposed	Any stains, splits, weathered paint on the walls of the bus port buildings, offices, shops, toilets, canteen shall be cleaned within 2 days
Flooring, Skirting, Dado finishes	Total damaged area shall not be more than 2% per 1000 sq.m.	Any damaged, missing, crack tiles in Flooring, Skirting, Dado finishes shall be repaired, replaced within seven days of detection

Item	Service Quality Criteria	Time allowed for repairs or Tolerance permitted
Staircases, Subways, Ramps	Clean and fully functional	These shall be cleaned at least twice a day. Damaged handrails, risers or treads shall be repaired within three days after detection.
Illumination (Lighting)	To meet the required illumination level as specified.	The ventilators, sky-lights etc. serving as source of natural ventilation and other luminaries for artificial lighting shall be cleaned once in seven days to maintain the illumination level.

7.5.2 *Periodic Maintenance Standards*

Apart from the routine maintenance works, the following periodic maintenance works should be carried out for the bus port **(see Table 7.3)**.

Table 7.3 Periodic Maintenance

Periodic Maintenance Activities	Time Limit for Maintenance/Renewal
Repainting of road furniture, delineators, markings etc.	Once in a year
Repainting of bus port Facilities	Once in three years
Repainting of carpentry work like joinery, doors, windows, ventilators, wooden furniture in the offices, cabins, booths etc.	Once in three years
Plaster Work	Plaster work shall be replaced every 7 years
Flooring Works	Glazed tiles and ceramic tiles floor should be replaced every 10 years. Kota stone floor should be replaced every 15 years. China mosaic flooring should be replaced every 10 years.
Roofing Works	Roofing sheet should be replaced every 20 years.
Water Proofing Works	Water proofing work should be replaced every 12 years.
Anti-Termite Treatment	Anti-Termite treatment should be done every 10 years.
Water Supply and internal drainage Pipelines	All water supply and internal drainage pipes to be painted with anti-corrosive paint. All pipes to be repainted every 3 years.
Resurfacing of Pavement	Cracks and settlements in rigid pavement shall be repaired. Joints to be redone after every three years.
Mechanical Equipment	Once in a year and as per manufacturer's installation, operation and maintenance instruction manual.
Electrical Equipment	Once in a year and as per manufacturer's installation, operation and maintenance instruction manual.

8. OTHER RELATED ELEMENTS

8.1 Multi-Level Car Parking (MLCP)

8.1.1 *Introduction*

Providing on and off-street surface parking has been the common practice, followed over years for parking in urban areas. Due to increase in vehicular population and limitation of space for surface parking, there is a need for development of multi-level parking spaces at the bus ports. In recent years, there is a shift, all over the world, to provide multi-level (also referred to as Multi storied) car parks. Multilevel car parks (MLCPs) require less surface area when compared to on or off-street surface parking, because in a MLCP, cars get parked at multiple levels – above, at or below ground level.

8.1.2 *Parking Technology*

The parking technologies can be primarily divided into the following:

(i) Ramp Based Parking

(ii) Semi-Automatic Parking Solution

(iii) Fully Automatic Parking Solution

(i) Ramp Based Parking

Ramp based parking systems are conventional parking systems where a multi- storied parking is constructed connecting with ramps. The vehicles are driven to the respective floors by the driver and are physically parked in the respective parking places.

(ii) Semi-Automatic Parking Solutions

The semi-automatic parking solutions include hydraulic based parking lifts (individual or in groups) that can be used in areas where there is shortage of space. Majority of the semi-automatic solutions are provided at surface parking to increase the parking capacity.

(iii) Fully Automatic Parking Solution

A series of coordinated vertical and horizontal movement of cars controlled by intelligent software systems inside a structure. Whole structure can be customized as per customer's requirements and limitations. Each level inside the parking system can be varied as per the dimensions of various cars – SUV's, compact cars etc. Reduced noise and air pollution levels in such systems; minimal chances of fire; no risk to human lives. Parking and retrieval times – average of 120 - 180 seconds per car depending upon configuration.

Ramp based Parking and Fully Automatic Parking come with their inherent benefits and limitations. The decision making process for the choice of technology for the MLCP solely depends on the type of site and its requirements. The following is a brief comparison of the key parameters for Semi-Automatic and Fully Automatic Parking **(Table 8.1)**.

Table 8.1 Semi-Automatic vs Fully Automatic Parking

Parameter	Ramp Based Parking	Semi-Automatic Parking	Fully Automatic Parking	Remarks
Area Required/ECS	35 sqm	20-25 sqm	18 to 22 sqm	Fully automatic systems are efficient in utilization of space and can generally accommodate more cars per floor
Floor Height	About 3.2 m	More than 4m depending on number of cars in each stack	About 2 m (Car height + 100mm) for pallet and pallet-less methods	Height/ Depth of fully-automatic parking complexes, for same number of floors, would be less than that for manual parking complexes
Ramps	Required	Required in case of MLCP	Not Required	For small plots, ramps waste larger % of the area thereby making manual systems inefficient
Lighting at parking floors	Required	Required	Not Required	No human interference in in fully automatic parking hence not required
Passenger lifts/escalators	Required	Required	Not Required	No human interference in in fully automatic parking hence not required
Passenger stair cases	Required	Required	Not Required	No human interference in fully automatic parking hence not required

Parameter	Ramp Based Parking	Semi-Automatic Parking	Fully Automatic Parking	Remarks
Markings/Signs on parking floors	Required	Required	Not Required	No human interference in in fully automatic parking hence not required
Marshals for Monitoring Traffic	Required on all floors	Required on all floors	Minimal requirement	Fully automated system requires marshalling only at I/O
Ventilation	Required (15 air changes per hour)	Required (15 air changes per hour)	Less Required (3 air changes per hour)	No human interference hence not required
Number of floors	Typically 3 to 4 floors	Typically 3 to 4 floors	No limit	
Safety and security	Manpower Intensive	Cumbersome-required on all floors	Minimal Requirement	Fully automated System
Operations and maintenance cost	Mainly manpower cost	Manpower cost + Electricity for operations + Equipment (Hydraulics)	Primarily Power cost + Equipment maintenance cost	
Indicative Capital Cost	8-10 lakhs/ ECS	10-12 lakhs/ ECS	11-13 lakhs/ECS	

Although the Automatic Multi Level Car parking has certain advantages in terms of space requirement and manpower involvement, however, with respect to a public transit facility like a bus port, the automatic car parking solution presents the following shortcomings:

8.1.3 *Development Norms*

A detailed study of the development norms of city where the bus port is planned, needs to be undertaken to identify potential barriers in the design and development of the MLCP and also to identify and incorporate any binding guidelines regarding the development of MLCP at the site.

The outcome of the aforementioned study may deliver the following:

- Minimum number of parking spaces
- Maximum FAR permissible
- Set backs
- Maximum Permissible height of the building

In addition to the above, the following ECS standards (minimum) for the parking norms are applicable for MLCPs **(see Table 8.2)**.

Table 8.2 Area Norms per ECS (Minimum)

S.No	Type of Parking	Area in Sq.mts
1	Open	22
2	Ground Floor Covered	28
3	Basement	32
4	Multi-level with Ramps	30
5	Automated Multilevel with Lifts	16

8.1.4 *Design Philosophy*

Design Philosophy forms the core around which the design takes shape. It is the study of assumptions, foundations, and implications of design which sets out a clear objective for the design and the vision to attain the said objective.

8.1.5 *IT-enabled Parking System, Centralized Parking Database*

This section discusses the option of infusing a higher degree of automation with the help of Information Technology Enabled Parking System with a centralized database and thus minimizing the manpower required. The following section discusses in brief about the IT-enabled Parking System components, equipment used and system architecture.

IT-enabled Parking System and Centralized Parking Database is significant for efficient operation and management of the MLCP. Various technology solutions shall be utilized as part of the IT-enabled Parking System and Centralized Parking Database.

Solution Components: The components of the technology solution would include the following:

- Boom barrier and entry and exit station based system
- Parking Ticket Issuance and Validation system with
- Bar-code enabled Hand Held Port (HHT) as a backup device
- Centralized database

8.2 Traffic Impact Assessment

It is a known fact that any new transport infrastructure development brings along additional traffic on the road network within its influence area. Infrastructure development like bus ports generates substantial pedestrian and vehicular traffic and puts pressure on the surrounding road network. Understanding the amount and nature of traffic that generates because of the new facility is vital

in addressing the impacts that are going to be created. Traffic Impact Assessment (TIA) study helps in predicting the kind of impacts like congestion on the adjacent road, traffic circulation or any other much before the actual implementation and act as a tool for identifying and estimating such affects so that appropriate mitigation measures can be taken up and implemented along with the development plan of the new facility.

TIA study assesses traffic and safety implications relating to a specific new development. These studies vary in their level of detail and complexity depending on the type, size and location of the proposed new development. The TIA study for a Greenfield or a Brownfield development is undertaken to assess whether the road network surrounding the proposed development will be able to handle the additional traffic that is going to be generated while maintaining an acceptable Level of Service.

This chapter presents the importance and process for conducting Traffic Impact Assessment studies for Bus Ports. It details out the various aspects to be considered while studying a bus port area, various surveys to be conducted, their respective importance and utilization of those survey results in efficient traffic planning.

8.2.1 *TIA - Activities and Benefits*

The key objective of the bus port is to ensure comfortable, convenient and safe movement of vehicles and the people using the facility for boarding and alighting the facility and all other functions intended to serve this purpose. To achieve this goal, one shall ensure smooth flow of the traffic and safety issues not only in the bus port vicinity, but also on the influence area outside the bus port. This is required to minimize adverse impacts of such bus port developments in that area.

The key objectives of the TIA study are:

a) To study the existing traffic characteristics and estimate the traffic likely to be generated by the proposed new development

b) To assess the impact of additional traffic on the road network system

c) To identify necessary roadway improvements and required changes to the site plan (example: entry/exit of the bus port etc.) of the bus port

d) To estimate the overall parking demand and prepare the plan

The envisaged benefits of Traffic Impact Assessment study are:

- Provides decision makers with various implications due to the new development and enable them to take informed decisions.
- Enable to understand the various traffic and safety issues such that appropriate mitigation measures are planned in advance in a timely manner.

- Provides a rational basis for planning various allied facilities, improvements that are required to provide safe and efficient traffic, pedestrian and transit flow, keeping in view the type and scale of the bus ports and based on site specific conditions.
- Addressing traffic circulation issues associated with development proposals that may be of concern to neighboring residents, businesses and other stakeholders.

8.2.2 *Methodology*

TIA study involves understanding of the prevailing traffic and roadway conditions in the influence area identify various challenges and estimate the improvements required in various horizon years.

There are various steps involved in conducting a TIA study. The detailed methodology and step wise procedure is discussed in the following sections. High-level study outline is given in the **Fig. 8.1** below.

The purpose of site reconnaissance is to provide details of the existing infrastructure and conditions within the study area for getting an understanding of the project, the location of bus port and other characteristics. It is recommended that a site visit must be conducted as part of TIA. The Reconnaissance can include the following **(Table 8.3)** (but not limited to).

Table 8.3 Site Reconnaissance

Proposed Development	Study Area	Existing Road Inventory	Existing Intersection Inventory	Major Development in the Vicinity
• Development • Type and location • Size of development • Horizon period – • Short term, medium term and long term	• Key Map • Site Plan	• Pavement width • Right of width • Existing/ Proposed accesses to bus port • Level of illumination • Traffic control type(i.e. two way or all-way stop control) • Traffic operation signage(no left turns no parking)	• Intersection configuration (2-arm, 3-arm etc.) • Junction control (uncontrolled, signalized etc.) • Signal timing	• Existing transit system inventory

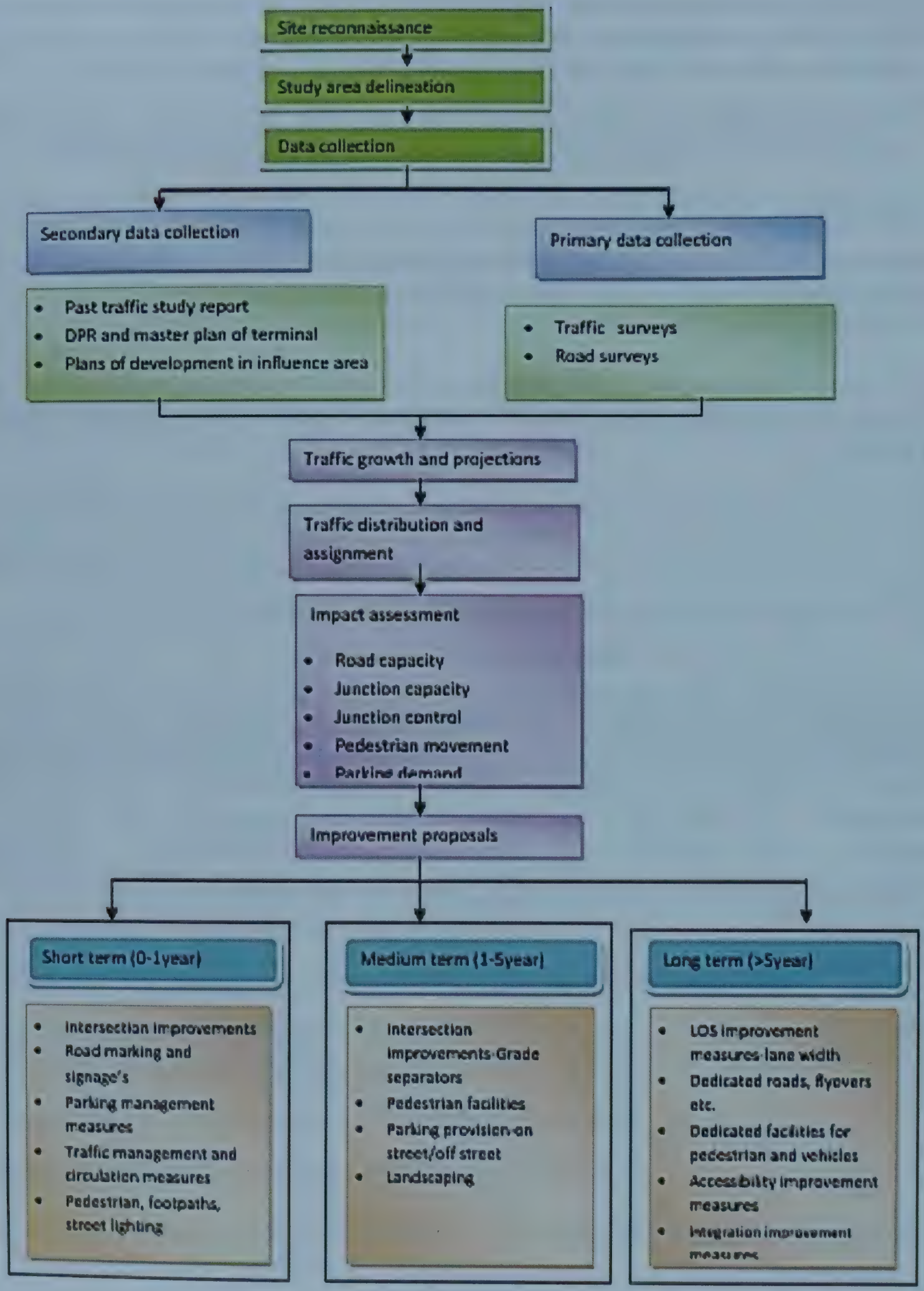


Fig. 8.1 Methodology for Traffic Impact Assessment for Bus Port

8.2.3 *Traffic Impact Assessment - Impact Dimensions*

As discussed in sections above, any new development like bus ports will have adverse impacts on the surrounding road network that mainly includes access points, intersections and key road sections. The negative impacts are in the form of congestion that causes excess delays, increased journey times and may also lead to more road accidents. All these impacts ultimately results in reducing the existing road and intersection capacities and, thus the Level of Service. Also,redesign ofothertransport-relatedinfrastructuremayberequiredsuchas installation or upgrading of street lighting, road signs, traffic calming measures, pedestrian facilities, and landscaping.

(i) Impact Analysis on Road Network

The TIA shall include a capacity analysis for the various road sections identified in the catchment area. Impacts should be evaluated for the design horizon of the project. Once the recommended developmental actions are identified, the analysis should be conducted including such actions in the appropriate horizon year to ensure desired results.

The road capacity analysis should carry out for following parameters:

Volume-Capacity Ratio for Road Sections: Volume to Capacity (V/C) ratio determines the level of congestion on the road network in terms of level of service, where a value of 1 or above signifies that the road network capacity is saturated.

This analysis is to be carried out for both peak hours i.e. morning and evening peaks.

Level of Service (LOS) Assessment: LOS is defined as a qualitative measure describing operational conditions within a traffic stream and their perception by drivers and passengers. LOS describes these conditions in terms of factors such as speed & travel time, freedom to manoeuvre, traffic interruptions, comfort, convenience and safety. LOS have been divided into 6 categories from A to F, with Level of Service-A representing best operation condition (i.e., free flow condition) and Level of Service-F representing worst operation condition.

The LOS of a Mid-Block Section is shown in the **Table 8.4**.

Table 8.4 LOS for a Mid-Block Section

LOS	Quality	Speed (kmph)	V/C	Description
A	Free-flow	80	0.60	High level of physical and psychological comfort
B	Reasonable free-flow	70	0.70	Reasonable level of physical and psychological comfort
C	Near free-flow	60	0.80	Local deterioration possible with blockages
D	Medium flow	50	0.85	Non-recoverable local disruptions
E	At capacity flow	40	0.90	Minor disturbances resulting breakdown
F	Congested flow	15	1.00	Break down of flow capacity drops

Source: The National Programme on Technology Enhanced Learning (NPTEL) notes on Capacity and Level of Service

Indian Roads Congress (IRC) has provided guidelines for evaluating the impact on road capacities in IRC:106 "Guidelines for Capacity of Urban Roads in Plain Areas". It is suggested that the methodology suggested in these guidelines may be followed for assessing the congestion levels at the bus port influence area.

(ii) Impact Analysis on Intersection Capacity

The Intersection analysis shall be carried out to evaluate the following parameters:

- Level of service (LOS) by intersection, turning movement & peak period
- Left-turn/right-turn movements (refer "IRC Codes" for warrants at intersections)
- Peak period traffic flow (AM & PM)
- Peak Hour Factor

Capacity analysis shall be performed at all proposed site access locations and all intersections in the study area. For each horizon year, the capacity analysis shall be conducted for conditions with and without the proposed development to determine the impacts of the proposed development and the improvements necessary to support each phase of the development.

The TIA shall provide capacity analysis results in a tabular form for all study intersections, study peak hour periods, and study horizon years listing the level of service [LOS], delay, queues and v/c [volume/capacity] ratio. In general, capacity analysis for study intersections and roadway sections should show an overall minimum LOS D as well as individual movement minimum LOS D using "IRC" guidelines. The LOS of an intersection is shown in the below **Table 8.5**.

Table 8.5 LOS for an Intersection

LOS	Signalized Intersection (delay/ vehicle in sec)	Un signalized Intersection (delay/vehicle in sec)
A	≤10 sec	≤10 sec
B	10–20 sec	10–15 sec
C	20–35 sec	15–25 sec
D	35–55 sec	25–35 sec
E	55–80 sec	35–50 sec
F	>80 sec	>50 sec

Source: The National Programme on Technology Enhanced Learning (NPTEL) notes on Capacity and Level of Service

Improvement of study intersections and roadway sections should be recommended for the following scenarios:

a. Overall LOS of intersections as well as individual movement LOS is worse than 'D'.

b. LOS of roadway sections is worse than 'D'.

c. Volume/Capacity [v/c] ratios for overall intersection operations or any individual movements (through, turning or shared through/turning movements) are 0.85 or above.

d. Queues for an individual movement are projected to exceed available turning storage based on the 95th percentile queue criteria.

In general, acceptable level of service for each intersection evaluated shall be as follows:

a. When the LOS without development is LOS A, B, or C, the minimum acceptable projected LOS shall be LOS C for all movement within a specific intersection.

b. When the LOS without development is LOS D, E, or F, the minimum acceptable projected LOS shall be LOS C.

(iii) Impact Analysis of Intersection Controls

In some urban & most of semi-urban areas, roads are un-signalized/uncontrolled at intersections. The turning movement count at junctions will help us determine the requirement of converting an uncontrolled junction to a controlled junction.

In some cases in urban and semi-urban centres, signals may already exist at an intersection. Analysis should be conducted to ensure that the current signal timings and phases are still valid. If not, new signal timings and turning phases should be recommended. In cases where the distance between signalized intersections is less, the analysis must consider the impacts of the development on the upstream/downstream signals. Exclusive bus lanes at the bus port accessing roads may be recommended.

8.2.4 *Safety Analysis*

Safety analysis may be needed depending on the characteristics of the proposed bus port development, its impact and the transportation system within the study area. These analyses may include accident analyses, sight distance, operational analyses, traffic calming and access management.

8.2.5 *Pedestrian Movement Analysis*

Pedestrian movement accommodation is an important issue for bus port planning in the urban and semi-urban areas. Depending on the structure & size of bus port and its interaction with the surrounding development, pedestrian movements can become a significant issue. Consequently, improvements to pedestrian facilities may be required. Pedestrian analysis should be conducted in line with IRC:103 and the recommended warrants should be used for proposing pedestrian facilities.

8.2.6 *Parking Demand Analysis*

Parking needs assessment shall be carried out for the horizon period without and with consideration of the development of the bus port. First stage in parking assessment is to identify the parking needs in the base year in the surrounding network of the proposed development through parking surveys. And the parking demand from the developmental traffic needs to be assessed and the future parking demand shall be assessed.

Parking requirements in the impact area needs to be diagnosed for any improvement proposals. The improvement proposals shall include (but not limited to):

(i) Traffic management measures to increase the effective road capacities;

(ii) Policy measures to encourage public transportation modes

(iii) Identify the gaps in the parking requirements compared to the supply and demand and suggest off-street or on-street parking enhancement measures.

IRC:SP:12 "Guidelines for Parking Facilities in Urban Roads" can be used a reference in addition to the parking studies for the recommendations of the improvement in the parking situation in the surrounding road network of the bus port.

8.2.7 *Public Transport Improvements*

TIA will also suggest measures to improve public transport system for catering to increased traffic load. Some of the improvements will include:

- Introduction of new feeder service
- Enhancement of existing service
- Adding new bus stops/adding capacity on existing bus stop or metro station

8.3 TIA Recommendations – Improvement Proposals

The Traffic Impact Assessment (TIA) should summarize the findings of the various analyses carried out including potential issues and clearly outline the recommendations regarding Short Term (0-1 yr), Medium Term (1-5 Yr), Long Term (>5 yr) improvement proposals:

A. Short Term Improvement proposals:

- Intersection Improvements-Signal Phasing
- Reorganization of the circulation system including two way, one-way and no way stretches for vehicular traffic
- Restriction of access to congested areas by modes of by time period
- Re-organization of on-street parking including identification of no-parking areas
- Identification of the development of off-street parking sites
- Facilitation of pedestrian movements to be convenient and safeby provision of footpaths, pedestrian plazas, pedestrian grade separated facilities along roads and at intersections.
- Provision of traffic signs and lane markings to guide, direct and channelize traffic flows
- Provision of street lighting
- Public Transport improvement measures

B. Medium Term Improvement proposals:

- Planning for Intersection Improvements – Grade separators
- Development of pedestrian facilities (like footpaths) for convenient and safe pedestrian movements, pedestrian plazas, pedestrian grade separated facilities along roads and at intersections
- Development of off-street parking sites
- Landscaping

C. Long Term Improvement proposals:

- Planning for the LOS improvement measures – lane width
- Planning for the dedicated roads, flyovers etc.
- Planning for the dedicated facilities for Pedestrian & Vehicles
- Planning for the Accessibility to the bus port
- Planning for the Integration of the bus port with other modes of transport

8.4 Passenger Amenities Assessment

8.4.1 *Communications and Multi-Modal Integration*

(i) Information

Passengers need to be provided with enough number of opportunities to feel comfortable and knowledgeable without asking for information from fellow passengers, which is often an unsecure means of transmittal of communication. Therefore, even when a passenger is not actively seeking information, a large part of communication still needs to be circulated related to bus arrivals/departures, facilities and amenities at the bus port etc.

Navigation can be made easier with several features including signs and design features, verbal communication and even mobile communication. Messaging system, Mobile Apps are possible ways of such communication. A bus port app can be useful by providing essential and timely information whenever the passengers need it.

The information of bus and other facilities can be provided using:

- Bus Port Apps
- Screensaver wall mounted display at bus port
- Digital displays table top units- "You are here" information

The Dissemination of Information through 3 Mediums is given below:

A passenger when looking for any bus information looks for the displays or information kiosk in the vicinity. A variety of mediums covering all passenger areas needs to be the guiding idea to provide information. This could be through signages, advertisments, digital displays, information cards, information kiosks and announcement.

Signage's need to be user-friendly and provide information essential to users, creating a sense of reassurance, security and orientation when entering, exiting or transferring. They should guide users to various areas, provide information of the bus ports and its services and provide information on bus services.

Further, visually challenged passengers should be able to get the bus status by announcements and information kiosks available. All bus and related information thus should be disseminated through 3 mediums as to provide quick information to passengers which will save time. Potential for several means of communication need to be explored. In the best case scenario, assistance in the form of "May I Help You" could also be explored as is used by the airlines industry at the airports.

(ii) Display of Safety Records

Regular announcements regarding keeping the luggage and belongings safe can alert the passengers to keep himself and his belongings safe at bus port. Documentaries can be run in

the waiting areas which show advertisements or related communication to alert the passengers with the possible criminal activity and safety measures.

Dedicated hoardings should be installed for women safety and helpline numbers. Women safety apps must work in coordination with bus port apps so that crime can be reported on urgent basis and action can be taken.

Help line desk and crime reporting desk must be there where complaints for missing luggage or other crimes can be registered and help can be provided. Any crime report or complaint registered in the bus can be registered through message or call on bus port app. Such links must be connected through apps, hoardings, helpline numbers, announcements and digital messages

(iii) Trains and Flight Info System

The passengers can get flight and train information through travel desk or digital displays. Separate kiosks or agent desk can also be provided based on the bus port planning. There could be wall mounted digital displays or hangings showing travel ticket or tour details so that passengers can contact for more information.

(iv) Trains and Flight Travel Agent

Providing such facility right at bus port can help passengers to ease their travel by avoiding going out and searching for ticketing of flights and trains. While they are waiting for their bus or moving out of bus, they can have all these facilities in the same area. It will save the time and promote better communication and travel experience. It becomes more safe and convenient as well.

(v) Estimated Real Time Arrival in PIS

A passenger information display/system (PIS or PIDS) is an automated system for supplying users of public transport with information about the nature and state of a public transport service, through visual, voice or other media. They are also known as Customer Information Systems and Operational Information Systems. Among the information provided by such systems, a distinction can be drawn between:

Static or schedule information, which changes only occasionally and is typically used for journey planning prior to departure.

High quality passenger information system is necessary at bus ports for the modern, predictable and competitive public transport.

Passenger information and traffic control system can be developed in a way that makes the estimation of the time of arrivals in every second and in every bus port possible – considering the interventions of the dispatcher, the real-time GPS-based observations (late and early status at the moment) and using the static time table.

Real time information, derived from automatic vehicle location systems, which changes continuously as a result of real-world events and is typically used during the course of a journey

(primarily how close the service is running to time and when it is due at a stop, but also incidents that affect service operations, platform changes etc.).

Real time information is an advance on schedule-only information, which recognises the fact that public transport services do not always operate exactly according to the published timetable. Provision of real time information to travellers boosts their confidence on public travel. This helps to encourage greater use of public transport.

Real-time information is provided to passengers in a number of different ways, including mobile phone applications, platform-level signage, and automated public address systems. It may include both predictions about arrival and departure times, as well as information about the nature and causes of disruptions.

(vi) Information of Bus Port at other Locations - Railways, Airport

Bus information regarding arrival and departure patterns can be made available at airports and railway stations by having digital screen inside or outside the premises so that passengers at airport or railway station can book the bus according to their requirement right their without searching outside. They can use the airport app and click on the links for bus information where the details can be linked. The tickets can be booked on the app or bus ticket counters available. It is necessary to link all these travel modes to make the entire journey an 'experience'. Passengers will be safer using the travel apps assigned by airport and giving genuine cost for the booking.

(vii) Information on Intermodal Connectivity- Distance, Time, Cost, Mode

The distances inside the bus port from entry till departure gates or the distances from the bus port to the intermodal connections like railway or airport should be adequately displayed by proving a signage or direction boards which mention the distance and way. It can be through hanging digital signage or wall mounted digital screens displaying the time and distance to reach these modes of travel. The cost can be written outside the ticket counters so that passengers can have idea before waiting in the ticket queue. These details can be highlighted in the bus port app and bus app, while travelling in the bus. The passengers can thus plan their next step travel and destination while sitting in the bus or while at the bus port itself.

(viii) Passenger Boarding Bridge for the Luxury Buses

Moving passengers from the bus port to the bus and from the bus back to the bus port, efficiently, expeditiously and safely is a major objective of efficient bus port operations. Usually passengers often leave the Port and walk outdoors to board the bus. For avoidance of such a situation, a Passenger Boarding Bridge (PBB) may be introduced in a bus port.

Passenger Boarding Bridge for the Luxury Buses Bus are the interface between a bus port and the bus. Bridges can make high end bus travel more appealing, safer, attractive and provide weather protection.

A Passenger Boarding Bridge is an enclosed, elevated passageway which extends from a bus Port gate to the luxury bus. The PBB allows passengers to board and alight a bus without the requirement to go outside or to be exposed to the elements. Passenger Boarding Bridges can be found in many configurations and may be fixed or movable depending upon the installation

Passenger Boarding Bridge is typically used with aircrafts for passenger boarding and disembarking. With advancement in technology and development of modern bus ports, passenger boarding bridges can be introduced at the bus port.

Passenger Boarding Bridges are mobile units which use an articulating mount to fasten them to the bus port at one end and are supported at the other end with the bridge between built as an extendable tube. This arrangement allows the bridge to be retracted and moved out of the bus during arrival and departure and, once the bus is parked and secure, announcement by a trained operator to come in contact with the bus at the desired boarding door. These units are adjustable to allow use with multiple buses and gates. Each will be directed to the few particular buses and gates.

It can be designed in such a way that it is divided into two passageways, each servicing a different bus door. It should be designed with dedicated engineering technology to help prevent accidental damage due to abrupt contact by the moving of the passenger bridge at bus port.

The advantages of a Passenger Boarding Bridge are numerous. These include:

- Safety - passengers are not exposed to the numerous safety risks present on a busy ramp area, temperature and weather extremes
- Ease of Access - access for the elderly passengers to reach the bus
- Passenger Comfort - the PBB is enclosed and often is also heated or cooled, as appropriate,ensuring thatpassengers are not exposedtoprecipitation orto extremes of temperature

8.4.2 *Customer Interface*

(i) Complaint Redressal - Housekeeping

A complaint redressal system can be designed for quick response to passenger complaints regarding housekeeping services at bus port. This can be done by starting the services in the bus port wherein the passengers can contact the on board staff through sms or phone call for complaints related to hygiene at bus port, toilets and other problems faced during the journey. The system will provide a common number like the one used for ticket enquiry which to which a passenger can send sms for any issue related to housekeeping like missing facilities or dirty bus, sittings. Once the sms is sent, the information will be registered on 'Online Passenger Complaint Redressal System'connected with the linked network, and it will immediately route to a network hand held unit (mobile phone) available with housekeeping supervisor nearby. Simultaneously, an acknowledgement would be sent on the mobile phone of the complainant with a complaint

ID with instruction to disclose the ID to the housekeeping supervisor after he attends to the problem. Housekeeping supervisor on receipt of passenger information would locate him, get briefing of his requirement and attend to the problem besides giving him feedback.

(ii) Feedback Surveys- Online and Paper Based

Passenger comfort is an important index that can be used to measure the quality of public transport services and a crucial factor in passenger choice of traffic mode. Passengers' judgments aboutcertain service attributes can be considered a subjective measure of transport service quality. Evaluating passengers' perception is a necessary prerequisite to improve bus travel comfort. The findings of the surveys can help bus operators and authoritiesdesign more appealingmeasures toimprovebusport comfort and improving public transportation in totality.

With many online survey software solutions, creating online surveys is simple and can be administered to target audience via email or social media networks within minutes. Because of this rapid distribution, sample population can respond almost immediately, and data is collected automatically. Sophisticated survey software systems provide real-time analysis tools so that the data gathered can be analysed. Some of the following kind of questions (given in **Fig. 8.2**) can be put in the survey formats depending upon the data required.

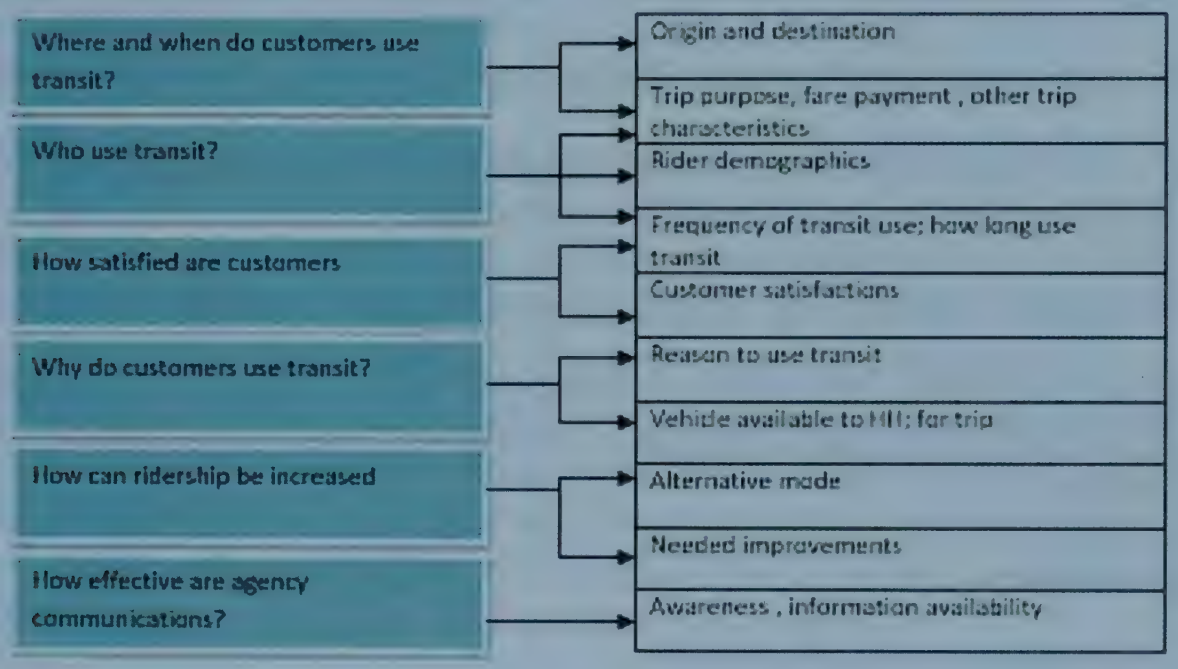

Where and when do customers use transit?
Who use transit?
How satisfied are customers
Why do customers use transit?
How can ridership be increased
How effective are agency communications?
Origin and destination
Trip purpose, fare payment , other trip characteristics
Rider demographics
Frequency of transit use; how long use transit
Customer satisfactions
Reason to use transit
Vehicle available to HH; for trip
Alternative mode
Needed improvements
Awareness , information availability

Fig. 8.2 Questions Can Be Put in the Survey Formats

For the purpose of understanding travel patterns and user preferences, passenger interviews or opinion surveys are conducted. These surveys can be conducted by various means:

- On-board surveys
- Intercept surveys
- Telephone surveys
- Web-based surveys
- Mail surveys

The responses can be used in the following applications to improve service.

- Route planning
- Long-range planning
- Schedule planning
- Modelling
- Changes in existing system elements

(iii) Lost and Found

Appropriate location should be chosen for a lost and found enquiry counter at bus port. The information of all lost things in the bus or at the bus port has to be registered with the officer at lost and found counter in electronic or paper format. Enquiry officer numbers to be displayed on the counter for the instant information to the passengers. The details should be provided at website as well. Following is the example showing contact numbers at website of Bus port on website and a Lost and Found Kiosk **(see Fig. 8.3)**.

Fig. 8.3 Lost and Found Kiosks

(iv) Housekeeping Practices

Maintaining public spaces like bus ports is a challenging job. Stained walls, paper and plastic wastes, smelly corners, dirty foot over bridges are a common sight at any bus port because of heavy foot fall each day. Despite the toilets being pay to use, users care little about leaving the toilets clean for the next user. At such public places, higher maintenance is required where the role of housekeeping becomes critical. Housekeeping at bus port is in itself a complete project of concern where lot of things need to be taken care of. A large team of housekeeping staff is required with different time shifts and responsibilities to maintain the bus port. For example, one

of the bus stations in Mangalore have deployed 53 housekeeping staff, seven supervisors, and one facility manager to maintain the area of approximately 4,16,930 sq.ft. The housekeeping management is also required who keeps giving demo to the cleaners for cleaning nearby buses to keep the equipment safe. The 3 prime areas where utmost cleaning is required at bus port are:

- parking area,
- waiting area and
- passenger boarding/alighting area.

The parking areas need sweeping and wash clean on regular basis. The office areas are deep cleaned with help of scrubbers. The waiting areas need regular brooming. There are separate coloured dusters to maintain different areas. There are masks and gloves to be used by housekeeping staff. Such kind of regulations and training is given to the housekeeping staff by trained team so that the public space must be maintained and hygienic environment is encouraged 24 x 7.

(v) Wheel Chair Assistance/Help Team

Wheel chair assistance includes services for disabled passengers like:

- Greeting service in front of the gate
- Wheelchair assistance
- Assistance for special needs
- Ticket and luggage

When incapacitated passengers travel, every effort should be made to make their journey comfortable and all necessary arrangements to be made in advance, in order to facilitate them. This requirement will be apparent from special requests made by the passenger or by their family or by a medical authority at the time of making a booking at the bus port.

There are categories of wheelchair assistance like disabled person, old age person, stretcher wheel chair, blind or deaf person, which can be mentioned in the app while booking or at the wheelchair assistance counter at bus port. Accordingly, the help can be provided. There can be separate queue for disabled/old age persons who need wheelchair assistance which can save their time and make the bus port experience easy and comfortable. It shall not only give wheelchair access but also provide assistance at the gate. The whole experience of disabled persons can become so easy through such facility.

(vi) Insects and Pests Management

Pest control is required at bus port to manage the insects or pest that impacts adversely on human activities. At bus port, these pests are the birds, insects and other organisms that share the habitat with humans and that feed on and spoil amenities and other areas.

Control of these pests is attempted through physical removal or chemical means.

- Hire a Pest Control Operator (PCO) certified in safer treatment methods
- The safest and least toxic products should be used
- Standards mentioned on the pesticide label regarding ventilation and waiting time before anyone can enter the sprayed premises should be strictly adhered to. For added safety, increase the waiting time and use a fan or other active ventilation.

8.4.3 *Building Aesthetics*

(i) Branding & Logo, Colour Scheme

The logo is the face of any brand; it's the very first impression while entering the bus port, so its design is extremely important. The logo or branding of bus port from outside is very important. It signifies the importance of a major public transport mode of that particular city. When executed correctly, a logo is a powerful asset to the bus port. A logo should be attractive and legible. The whole point of creating a logo is to build brand recognition. The key to making a popular and recognizable logo is to combine all of the design elements like size, style, colour, typography, and originality. Therefore, it should be seen from all angles to ensure that it's recognizable from any direction while standing at the bus port.

Being it a public transport building, colour scheme for exterior can be neutral shades which may blend with bright colours for few design elements. Too bright colours throughout can be discomforting to the eyes and can possibly distract a passenger while looking for signage, hoardings, or any other brandings. The bright colours can be taken for signage, hoardings, and barriers, ramp edges for visually impaired passengers or logos to take the attention of viewer.

A bus port can look good with using basic neutral shades and materials which can give natural texture appearance. Addition of natural stones, with blend of glass or metallic ACP sheets can add to the modern look of a building.

Design guidelines should be regulated to obtain the total development character and aesthetic including Architectural Façade (Elements, Material, Colour) and Site Development Specifications (surface finishes & colours, heights) and External Area Maintenance. The built form has to be conceived to create a new identity for the urban pocket. Material choice for the exteriors is proposed to match with the external ambience. As per new urbanism trends in the architectural treatments of building sensitive use of glass, natural stone and composite panel finishes to be added.

Bus Port branding is a great medium of visibility for the brands. It is a cost effective medium to promote brand and spread awareness. Being the daily commuting source for many of the passengers, Bus Port becomes one of the most important sources of branding where lakhs of passengers may view the brandings.

Branding of products is a potential source of revenue for the bus port. Branding can be done on buses, dedicated walls can be provided for brandings by various commercial products, digital displays, charging stations of assigned brand can be placed, branding of food can be done. The branding should not obstruct the view of passengers from the buses, and important directional signage or time displays. It should be planned according to the bus port facilities and dedicated space with sizes has to be provided before providing signage space.

(ii) Cultural/Social/Civil History (Information)-Photographs-Places to Visit

A bus port can serve much more than a transit space. It is the right space to display the cities art, culture and history because of daily passenger activities. Bus Port functions as the centre of many communities, often with thousands of people passing through them on a daily basis. If a station is afflicted with a retaining wall or blank wall, fun aesthetic treatments can be applied to transform it into something productive and attractive.

- Create comfortable, image able stations
- Multi-use destination
- Policy initiatives such as value capture, development incentives, zoning changes, shared parking
- Wall displays as exhibition spaces to cultural artists and small scale industry
- Public art with blend of functional spaces
- What to do in the place, events calendars, and nearby businesses and attractions

At such a socially and culturally active transit port, you are no longer look out of place waiting for bus. You are just another participant in an exciting civic realm. Transit is a component, but by no means the extent, of your memorable experience in this place.

(iii) Murals/Paintings/Statue/Fountains

Public art is art in any media that has been planned and executed with the intention of being staged in the physical public domain, usually outside and accessible to all. Bus Port is one of most used public spaces wherein large number of passengers commutes daily. They come to the bus port and goes to ticket counter, checks the digital signage, use the facilities and take the bus facility in the scheduled way. In this course of time, the passengers waits in the sitting area, walk toward his destination and while these activities goes on, several spaces comes in between which can be modified to an interesting space which gives a sense of 'experience'.

Bus port should be used for travel but the travel should become an 'experience'. The experience can be made better by introducing attractive murals to the walls, adding paintings to the columns, parking spaces, walls and furniture used in the vicinity, creating statues with the lightings, adding fountains on the entrance space. All these elements are not to be considered an extra element of adding up cost but can be included in the planning and design since starting of the concept

stage. The elements like lightings, dustbins, shelters, walls, sittings can be designed in a way to give sense of visuals, a pleasing appeal which in totality give it a different and unique look to the Bus Port.

(iv) Music & Lighting

Lighting levels must meet the current regulation standards for public transport facilities and signage. Since bus ports are a subject of public interest, the decision to install lighting at a Port site is influenced by cost and availability of power (electricity). During daylight, the use of translucent materials and structures which emulate an open and spacious design, helps achieve a more naturally lit port environment, and economic lighting provisions.

The lighting for the Central Bus Port in Munich aims at giving the appearance of a building floating on a cushion of cold white light. As a result, warm light is used in the upper floors and in the exterior space while a softly shimmering façade evokes a powerfully glowing orange.

Floodlights integrated within the long façade of aluminium tubes. The banner on the retail, restaurant and café level is brilliant orange, and has advertising for all the companies in the building. The banner is evenly illuminated by floodlights with glare reduction. The bus port level is illuminated and is transformed into a large, highly contrasted area covering nearly 9,000 square meters after nightfall.

Combining light and architecture fills a Bus Port with atmosphere and gives visitors an opportunity to view a space in a whole new way. Adding light sculptures can enhance urban spaces by turning them into desirable places to visit and making spaces large and small feel safe, welcoming, and interesting.

The right light can:

- Help to improve the perception of a space, making it feel safer, more modern, and more desirable as a place in which to spend time
- Create space more visible and attractive to outside visitors
- Celebrate place, historical heritage, and local characteristics

Music can be introduced at the Bus Port creating soothing and comfortable environment for the passengers. A pilot scheme at Huddersfield's Upperhead Row station has been a success where Classical music had been used. Recorded music has been appreciated as it was very positive with passengers providing'soothing atmosphere' while waiting for their bus.

The **Table 8.6** below shows the required levels of lux according to the function in a bus port

Table 8.6 Required Lux Levels

S.No.	Function	Lux level
1	Waiting Rooms	150
2	Ticket Counters	1000 (Min 500)
3	Accounting Office	1000 (Min 500)
4	Office in General	500 (Min 250)
5	Canteen	150
6	Platforms/Concourse	150
7	Ground Floor Entrance Lobby and Lift	120
8	Lift Lobby of Upper Floors	85
9	Small Item Storage	300
10	Food Preparation and Cooking	500
11	Bars, Dining Rooms	50-200
12	Toilets/Corridors/Stairs	150
13	Sign Surface	12
14	Canopied Areas	150
15	Parking Bays and Driving Lanes	75
16	Site Entrance and Exits	250-300
17	Garage(General lighting)	500 (Min 200)
18	Washing Area	500 (Min 250)
19	Parking Lot	150

Source: labor and welfare bureau of the government of Hong Kong Special Administrative region

8.4.4 *Value Added Services*

(i) Seating – Roller Chair/Lounge/Reactive Chairs

Seating in and around the bus port complex shall be planned to cater to a minimum of 30% of all passengers in the facility. Seating is required so as to avoid obstruction to the flow of passenger traffic through the complex; it should be designed to combine comfort, ease.

Waiting areas and lounges in bus port are typically very minimalist, meaning the furniture ends up being the focal point of an area. The furniture itself needs to be able to seat many people, but also be comfortable for those who have a long time to wait. It must be compact and comfortable.

Whether at the departure gate, restaurants, or public waiting areas, bus port seating needs to be comfortable and fit with the décor of the bus port.

More understated and simple chairs, like metal chair are perfect for weary travellers or people waiting to pick someone up at the bus port. They can easily fit together to provide seating for hundreds of people at a gate. These styles are also available in a variety of materials and colours to match with the look of the airport. They are easy to keep clean and can handle heavy use. In

bus port lounges, the furniture still needs to be understated, but can be a little more lavish and spaced out than in a general waiting area. It can be armchairs and sofas which look good and comfortable.

(ii) Hotel Reservation Counter

Hotel reservation counter is required at bus port to ease the passengers by saving time and searching for hotel after coming out of Port. Reservation becomes easy and safe from the genuine system at bus port and it can be merged with the taxi drop off till the hotels. A small kiosk can be planned for the hotel reservation and information like type of hotels, place of hotels etc. with the charges can be available.

(iii) Travel Desk – Taxi/Prepaid Counter, Railway Ticket

To connect the different travel mode and make ease for passengers, taxi booking counters and railway ticket booking counters to be planned at the bus port. While the passengers wait for their buses or while coming back from the destination, they can easily book the taxi to the hotel or other destination right from the bus port, without coming out and waiting for local taxi. The prepaid taxi from bus port becomes safer and convenient for the passengers.

The Indian railway booking counter can connect the passengers to rail mode right at the bus port without going to railway station or any other travel agencies for railway booking. It is more convenient to give a booking counter. It also provides all information of running trains and their timings thus to aware the passengers about all railway enquiry there at the bus port.

(iv) Lounge Bar

Bar is a counter in a pub, restaurant, airport or a bus port across which drinks or refreshments are served. Lounge is a pub with relaxed sitting arrangements. A bus port lounge bar is a facility which offers more comfortable seating and quieter environment.

- Escaping the Stress of Travel at bus port Lounge Bar with:
- Snacks and appetizers
- Alcoholic/Non Alcoholic beverages
- Newspapers and magazines
- Free Wi-Fi
- Shower facilities

A bus port lounge is an added advantage to the passengers who want to use the facility while waiting for the buses. There could be variation in the facilities provided inside the lounge bar based on the city culture, number of passengers travelling and size of the bus port. Metropolitan cities have larger footfall and many people travel for business purpose. While waiting for the bus, they need a private lounge to discuss the meetings or just to relax. It can be designed or planned as per the demand and membership cards can be planned for the lounge bar access to maintain its facilities.

(v) Medical Store, Doctor Provision and First Aid

A first aid room or medical room is a room in an establishment to which someone who is injured or ill on the premises can be taken for first aid and to await the arrival of professional emergency medical services. It is necessary to provide medical store, first aid facility and preferably doctor provision at bus port.

(vi) Shoe Shine

Rotary motors and brushes are used in the shoe shiner machine. Highly reliable, efficient, hygienic aesthetic design suitable for bus port where lot of passengers travel on daily basis. Shoe shine machine provide a perfect shine in a convenient, quick and easy way. Such facilities need very less space at the bus port without disturbing the spatial planning. It can be easily movable and can be shifted to other place.

8.4.5 *Information Technology*

(i) Free Wi-Fi

Many of the bus ports, airports and metro rails have started to provide free Wi-Fi facility for the commuters. At few places, secured Wi-Fi connectivity to all commuters at the terminus is given so that commuters will able to browse the Internet free of cost for the first 30 minutes. Later it becomes chargeable with some decided cost mentioned while connecting the Wi-Fi with the mobile phone. In 2013, the Indian Railways had launched a pilot project to provide Wi-Fi facility on Howrah Rajdhani Express. The organization was planning to offer a 4 Mbps download and 512 kbps upload connection through this service. It had also informed that the service will be extended to other Rajdhani, Shatabdi and Duronto express trains based on customer feedback received during the pilot. Besides this, several Airports in India including Bangalore, Delhi and Mumbai airports also offer free Wi-Fi service for a limited time.

(ii) Mobile Charging Stations

Charging stations solve a problem for their passengers. There are solutions for the anxiety of having a low battery or a cell phone without a battery, and in a world where all people use their mobile phones every day, customers will search for sites that offer a solution to their problem.

(iii) GPS Tagging on Luggage

GPS, is at the vanguard of an exciting new phase in locating technology that might end everything from missing luggage to tracking of children. This technology can be used in the mall, entertainment zones, airports and even bus ports.

A dedicated space can be planned where passengers can come after taking tickets and purchase the GPS tagging for luggage and children for nominal fee. It can be clubbed with the ticketing system, luggage checking system and entrance depending upon the schematic plan prepared for GPS tagging. Such facility helps passengers to easily track the luggage and their children while travelling.

8.4.6 *Environment*

(i) Dust Suppression System

Dust Suppression System is a technology for controlling dust at manufacturing, industrial and agricultural sites or public spaces. With this system, dust can be suppressed before it becomes airborne. It produces an ultra-fine water fog that effectively attracts and holds dust particles so that they can be more readily removed from the work place and other environmentally sensitive areas. In a typical application, system can also deliver highly effective odour neutralizing agents. It can be used at bus port to create clean environment conditions for the passengers.

Dust Suppression System uses high pressure water fogging which creates an ultra-fine fog consisting of very fine water droplets (less than 10 micron size). (Defined as Dry Fog) in diameter. These tiny water droplets absorb even the smallest dust particles in the air, yet fall to the ground without wetness.

Dust Suppression System requires no costly air compressors, making the initial outlay lower than a ventilation type control system. Low water and electricity consumption, save running costs.

(ii) Bus Washing

Bus wash system at the bus port helps in washing of bus right at the bus port using little standard equipment. The roll over or manual bus wash systems are available based on every possible budget and requirement. Each wash system is well suited to high volume bus depots or ports bringing to bear various unique advantages that deliver wash quality and low ongoing service and maintenance costs. It can be easily operated at site because of the standard sizes and operating systems.

(iii) Effluent Treatment Plant

ETP (Effluent Treatment Plant) is a process design for treating the industrial waste water for its reuse or safe disposal to the environment.

- Need for the ETP:
- To clean industry effluent and recycle it for further use.
- To reduce the usage of fresh/potable water in Industries.
- To cut expenditure on water procurement.
- To meet the Standards for emission or discharge of environmental pollutants from various Industries set by the Government and avoid hefty penalties.
- To safe guard environment against pollution and contribute in sustainable development.

Effluent treatment plant or wastewater treatment plant are further categorized into Chemical treatment, Biological treatment, combination of chemical & biological treatment.

8.4.7 *Augmented Value Services*

(i) Freshen up & go –Time Capsules

Restful travel hideaways are nothing new, but the recent spread of relaxation lounges around the world shows that demand is higher than ever. These relaxing rooms are provided at most of the airports and can be planned even at bus ports to make them better for the passengers in terms of facility and luxury services.

Indira Gandhi International Airport Delhi has added a new dimension to the airport lounge. An innovative concept has been introduced called sleeping pods and pay-per- use lounges, offering personal comfort spaces. Similar freshen up and go spaces can be created at bus ports to give passengers comfort and relaxing time while travelling from one place to another.

(ii) Food Court

A food court at bus port shall be an indoor plaza or common area within a facility that is contiguous with the counters of multiple food vendors and provides a common area for self-serve dinner.

Food courts have also come to replace or complement traditional cafeterias. Food courts consist of a number of vendors at food stalls or service counters. Meals are ordered at one of the vendors and then carried to a common dining area. The food may also be ordered as takeout for consumption at another location, such as waiting lounge or even bus.

As food is a huge aspect of culture and diversity, consumers have been intrigued with the fusion of food at such food courts.

(iii) Children Activity Area

Children activity area includes play activities, indoor swings, kids' books and workshop space to engage the children with fun activities while waiting for the buses or while the parents are booking the tickets at bus port.

It provides a safe, fun and nurturing space for children to play, learn and wait at bus port. Under the supervision and care of trained professionals, parents get to leave their kids at such area, without a second thought. Bus port travel for kids becomes wholesome, wonderful and memorable.

(iv) Trolleys/Porter

Bus ports should have small trolleys to carry hand bags security-check to bus gates for all passengers. With the expansion of bus ports, distances to bus have increased, thus, passengers comfort must come into action by providing better facilities like trolley provisions.

(v) Product Specific Kiosks

Kiosks can be a booth with a person who handles the selling products and their transactions. These non-interactive or manned kiosks are still popular among businesses today and can be found in a wide variety of locations, including city streets, shopping malls, airports and bus ports. Product specific kiosks refers to the kiosks which are selling products like clothing, toys, books-magazines, soft drinks and snacks, gift items, mobile accessories.

Kiosks can provide your customers with detailed information about your products and services. Since kiosks are often placed at strategic locations, kiosks brands would be able to reach more potential customers.

Vending kiosks directly sell a product. They were previously only used to issue tickets, but have now expanded to dispensing small, basic items, such as cold drinks and packed snack items. Modern customers demand more interactive features when making their purchase decisions. This is why more and more companies are incorporating kiosk technology into their operations.

(vi) ATM

An Automated Teller Machine (ATM) is an electronic telecommunications device that enables customers to perform financial transactions, such as cash withdrawals, or obtaining account information, at any time and without the need for direct interaction with bank staff. It is required to be located at Bus port because lot of passengers travel on daily basis from one place to another and do not carry so much cash during their travel

ATM is the safest mode of withdrawing cash in a quick way. ATM card carrying is easy for travel these days so it can be withdrawal from various ATM machine locations inside or outside bus port. It should be uniformly located so that passengers don't have to walk the entire bus port searching it. It should be located near entrance, exit, food zone, ticket area, waiting area, shopping zone.

8.4.8 *Parametric Evaluation Matrix of a Bus Port*

Table 8.7 and Table 8.8 presented parametric matrix can be used for the evaluation of a bus port.

Table 8.7 Planning and Design Parameters for Evaluation of Bus Port

S.No	Parameter	Maximum Score
A)	**Planning and Design Parameters for Bus Ports**	**600**
1	**Infrastructure Assessment**	100
1.1	Bus Bay Adequacy and Design	20
1.2	Entry/Exit Points And Circulations	20
1.3	Parking and Pickup Drop off Facilities	20
1.4	Provision for Pickup/Drop off and Parking	20
1.5	Pedestrian Dispersal Facilities	20
2	**Bus Movement**	**180**
2.1	Bus Types	20
2.2	Turning Radii	20
2.3	Road Surfacing	20
2.4	Decelerating Lane	20
2.5	Lane Width	20
2.6	Gradients	20
2.7	Intersection	20
2.8	Horizantal and Vertical Clearances	20
2.9	Bus Bay System and Suitability	20
3	**Multi-Model Integration**	**50**
3.1	Accessibility of Footpaths'	10
3.2	Accessibility of Pedestrian Crossing	10
3.3	Accessibility	10
3.4	Time of Access	10
3.5	Ease of Access	10
4	**Universal Access**	**100**
4.1	Pedestrian Access	10
4.2	Entries and Exits	10
4.3	Pedestrian Entries and Exits	10
4.4	Entry Courts	10
4.5	NMT or IPT	10
4.6	Car Drop off and Parking	10
4.7	Pick-up and Drop off Lane	10
4.8	Visibility Impairment Zones	10
4.9	Designing for the Visually Impaired	10
4.10	Designing for the Mobility Impaired	10

5	**Safety and Security**	**40**
5.1	Design Considerations	10
5.2	Electronic Surveillance	15
5.3	Illumination	15
6	**Water Management Practices**	**50**
7	**Power Sustainability: Emergency power, renewable generation**	**50**
8	**Heating, Ventilation and Air Conditioning for Large Areas**	**30**

Table 8.8 Qualitative Parameters for Evaluation of Passenger Amenities

S.No.	Parameters	Maximum Score
B)	**Qualitative Evaluation of Passenger Amenities**	**400**
1	**Communication and Multimodal Integration**	**80**
1.1	Information-(Bus information/Terminal Information/Navigation) -at least three Mediums-Mobile App, Led Screens, Public Announcement, Information Kiosks	15
1.2	Display of Safety Records-Days Since last Pick Pocket, other Incidences, Prepaid Taxi/Auto Booths.	10
1.3	Real time Information Display for Trains and Flight (Arrival, Departure)	10
1.4	Travel Agency (Hotel, Ticket Bookings, Guide, Taxi)	5
1.5	Estimated Real Time Arrival in PIS	10
1.6	Real time Information Display for Buses at Railway Stations and Airports (Arrival, Departure)	10
1.7	Information on Intermodal Connectivity-Distance, Time, Cost, Mode, Signage, Assistance to reach	5
1.8	Television Program	5
1.9	Passenger Boarding Bridge for the Luxury Buses	10
2	**Customer Interface**	**50**
2.1	Complaint Redressal	10
2.2	Feedback Surveys-Online and Paper Based	10
2.3	Lost and Found	5
2.4	Housekeeping Practices	5
2.5	Wheelchair Assistance/Help team	10
2.6	Insects, Pests Spray Management	10
3	**Building Aesthetics**	**30**
3.1	Branding and logo, Colour Scheme	5
3.2	Cultural/ Social/Civil History (information)-Photograph, Tourist Places to Visit	10
3.3	Murals/Painting (and their Reproductions)/Statue/Public Space condition	10
3.4	Music and lighting system	5

4	**Value added Services**	**90**
4.1	Lounge Room-Better Seating-roller Chair (Lounge/Reactive Chairs), Tie-up with Hotel/Credit Card/other Corporate from Hospitality Sector	25
4.2	Help on the Move-Welcome/Assists in Lobby and other part of Bus Ports	30
4.3	Media/Television	5
4.4	Lounge Bar	10
4.5	Medical store, Doctor Provision and First Aid	10
4.6	Smoking Room	5
4.7	Shoe Shine	5
5	**Augmented it Based Facilities**	**30**
5.1	Wi-Fi	10
5.2	Mobile Charging Ports	5
5.3	GPS Tagging on Luggage	5
5.4	Child Tracking Bands	10
6	**Environment**	**60**
6.1	Dust Suppression System	30
6.2	Bus Washing	15
6.3	Effluent Treatment Plant	15
7	**Augmented Value Services**	**60**
7.1	Time Capsules	25
7.2	Children Engagement Area	5
7.3	Trolley, Porters	10
7.4	Product Specific Kiosks for Travel	5
7.5	Automated Teller Machine (ATM)	5
7.6	Child Care Facility	10

Based on the scoring for each parameter and the final points received for the bus port, the following is the rating of bus port **(see Table 8.9)**:

Table 8.9 Rating of Bus Port

Score Range	Rating
>849	5 star rating
>799	4 star rating
>699	3 star rating
>599	2 star rating
>499	1 star rating

9. CASE STUDIES

Various Design Parameters considered for three Bus Ports in India includes Faridabad, Kolkata, and Vijayawada are presented at **Table 9.1, 9.2** and **9.3** respectively.

Table 9.1 Various Design Parameters considered for Faridabad Bus Port

City Name	Parameters	Units	Details
Faridabad (Ballabhgarh)	Population of the City (2011 census)	in lakhs	18.09
	No of Bus Ports in the City	in no's	2
	Port Name	Specify	Ballabhgarh ISBT
	Function of Port	Specify	Inter-city & Interstate
	Port Area	In Sq.Mts	80937
	Surrounding Land use	Specify	Commercial
	Number of Entry/Exit gates to the Bus Port	in no's	Entry-1, Exit-1
	Circulation inside Port-One way/Two way	One/Two	Two way
	Demarcation/markings for circulation	Yes/No	No
	Bus bays configuration (Parallel/Angular etc.)	Type	Parallel
	Total bays (inter-state, inter-city & Intra-city)	in no's	12
	Separate bays for Alighting & Boarding?	Yes/No	No
	Idle number of bus parkings	in no's	80
	Passenger footfall in a average day	in no's	14000
	Government buses handled daily	in no's	310
	Private buses handled daily	in no's	1
	Number of Buses handled by the Port daily	in no's	311
	No of buses handled in a peak hour (Departure)	in no's	15
	Average dwell time of the bus	in mins	25 minutes
	% of through buses	%	0%
	% of destined buses	%	100%
	Pick up and drop zones in the Port	Yes/No	No
	Other Pickup and drop off facility in City	in no's	3
	Multi-modal integration	Yes/No	Yes
	Designated parking area for Cars & TWs	Yes/No	No
	IPT (Taxi/Auto/Cycle rickshaw)	Specify	No
	Footpaths in surrounding network of the Port	Yes/No	No
	Other transport facilities in the Port	Specify	No

Table 9.2 Various Design Parameters considered for Kolkata Bus Port

City Name	Parameters	Units	Details
Kolkata	Population of the City (2011 census)	in lakhs	18.09
	No of Bus Ports in the City	in no's	2
	Port Name	Specify	Karunamoyee Bus Port
	Function of Port	Specify	Intra-city, Inter-city & Interstate
	Port Area	In Sq.Mts	17941.5
	Surrounding Land use	Specify	Institutional & Residential
	Number of Entry/Exit gates to the Bus Port	in no's	Entry-2, Exit-3
	Circulation inside Port-One way/Two way	One/Two	Two way
	Demarcation/markings for circulation	Yes / No	No
	Bus bays configuration (Parallel/Angular etc.)	Type	Parallel
	Total bays (inter-state, inter-city & Intra-city)	in no's	25
	Separate bays for Alighting & Boarding?	Yes/No	No
	Idle number of bus parkings	in no's	40
	Passenger footfall in a average day	in no's	52000
	Government buses handled daily	in no's	200
	Private buses handled daily	in no's	50
	Number of Buses handled by the Port daily	in no's	250
	No of buses handled in a peak hour (Departure)	in no's	55
	Average dwell time of the bus	in mins	15 minutes
	% of through buses	%	4%
	% of destined buses	%	96%
	Pick up and drop zones in the Port	Yes/No	No
	Other Pickup and drop off facility in City	in no's	3
	Multi-modal integration	Yes/No	Yes
	Designated parking area for Cars & TWs	Yes/No	No
	IPT (Taxi/Auto/Cycle rickshaw)	Specify	Auto & C.Rick.
	Footpaths in surrounding network of the Port	Yes/No	Yes
	Other transport facilities in the Port	Specify	No

Table 9.3 Various Design Parameters considered for Vijayawada Bus Port

City Name	Parameters	Units	Details
Vijayawada	Population of the City (2011 census)	in lakhs	10.48
	No of Bus Ports in the City	in no's	3
	Port Name	Specify	
	Function of Port	Specify	Intra-city, Inter-city & Interstate
	Port Area	In Sq.Mts	89840
	Surrounding Land use	Specify	Commercial
	Number of Entry/Exit gates to the Bus Port	in no's	Entry-1, Exit-1
	Circulation inside Port-One way/Two way	One/Two	One way
	Demarcation/markings for circulation	Yes/No	No
	Bus bays configuration (Parallel/Angular etc.)	Type	Angular
	Total bays (inter-state, inter-city & Intra-city)	in no's	68
	Separate bays for Alighting & Boarding?	Yes/No	Yes
	Idle number of bus parkings	in no's	100
	Passenger footfall in a average day	in no's	128000
	Government buses handled daily	in no's	7005
	Private buses handled daily	in no's	0
	Number of Buses handled by the Port daily	in no's	7005
	No of buses handled in a peak hour (Departure)	in no's	350
	Average dwell time of the bus	in mins	15 minutes
	% of through buses	%	40%
	% of destined buses	%	60%
	Pick up and drop zones in the Port	Yes/No	Yes
	Other Pickup and drop off facility in City	in no's	5
	Multi-modal integration	Yes/No	Yes
	Designated parking area for Cars & TWs	Yes/No	Yes
	IPT (Taxi/Auto/Cycle rickshaw)	Specify	Auto
	Footpaths in surrounding network of the Port	Yes/No	No
	Other transport facilities in the Port	Specify	Subway

Fig. 9.1 Bird View of Pandit Nehru Bus Station Vijayawada, Andhra Pradesh State

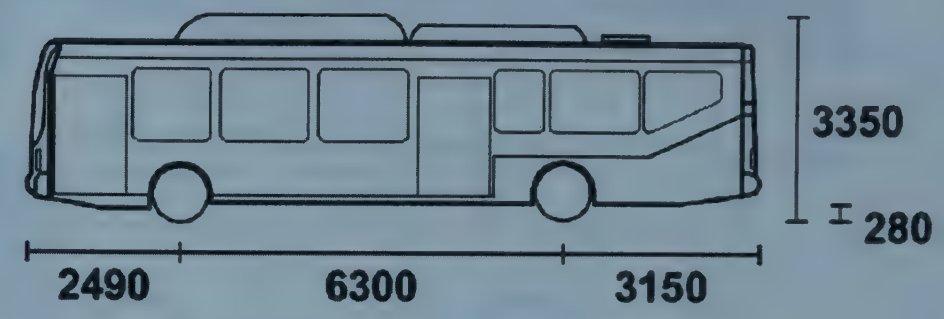
Fig. 9.2 Pedestrian Safety Measures at Pandit Nehru Bus Station Vijayawada, Andhra Pradesh

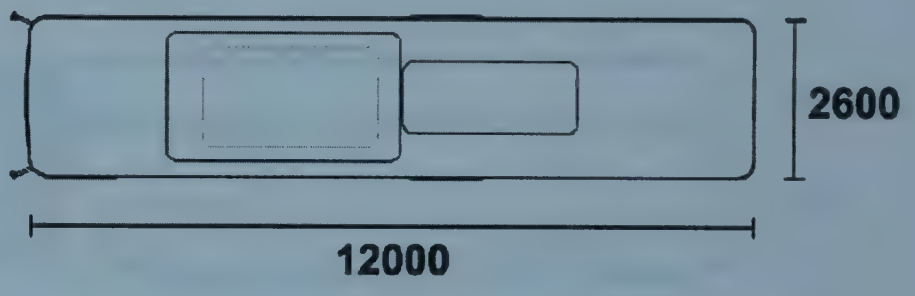
ANNEXURE

TYPES OF BUSES

The different types of buses along with their dimensions and descriptions are shown below.

(a) Low Floor Bus



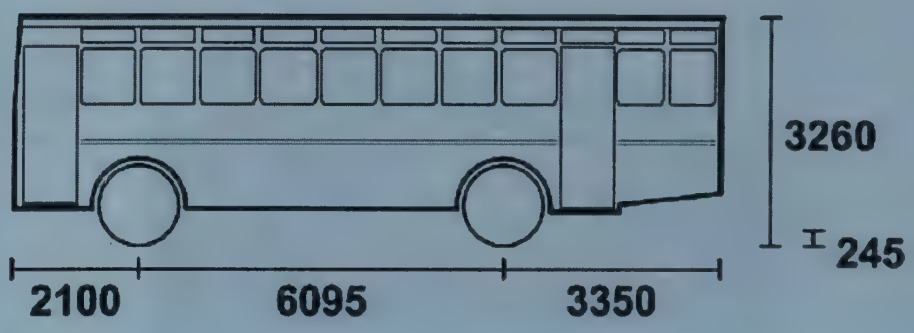


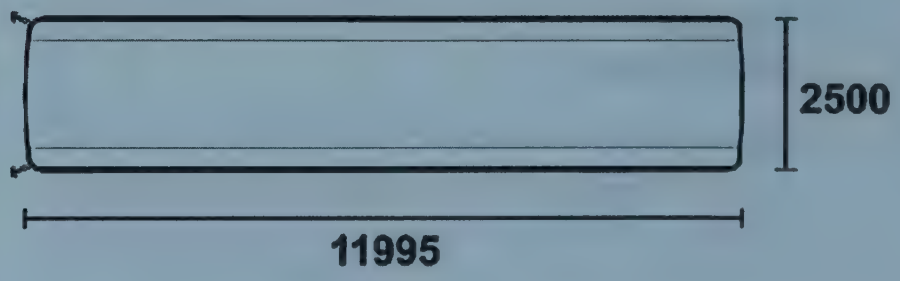
Examples:

- **DTC buses.**
- **Haryana Roadways Faridabad.**
- **Haryana Roadways Gurgaon.**

The floor height is 400 mm (15.75")

(b) High Floor Bus





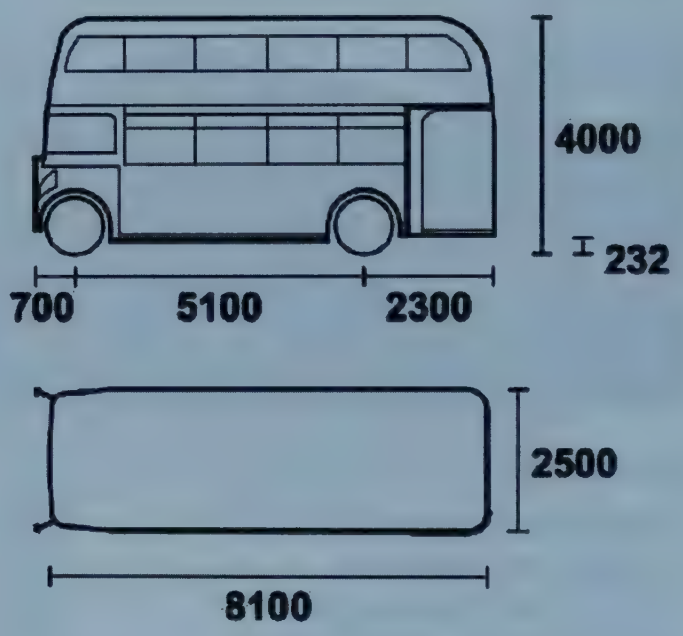
Examples:

- **Haryana Roadways.**
- **Punjab Roadways.**
- **Himachal Roadways.**
- **DIMTS (but wider doors).**

(c) Extra Long Bus

Extra-long (54 to 60 feet) bus with the rear body section connected to the main body by a joint mechanism. The joint mechanism allows the vehicle to bend when in operation for sharp turns and curves and yet have a continuous interior. It can hold about 60 passengers.

(d) Double Decker Bus

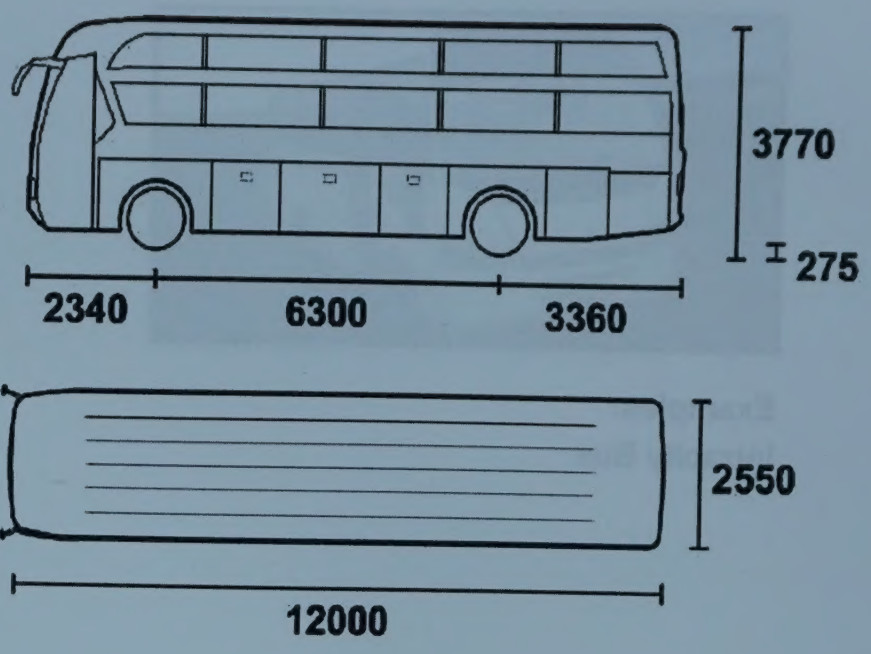


Examples:
BEST Mumbai.

High-capacity bus having two levels of seating, one over the other, connected by one or more stairways. Total bus height is usually 13 to 14.5 feet, and typical passenger seating capacity ranges from 40 to 80 people.

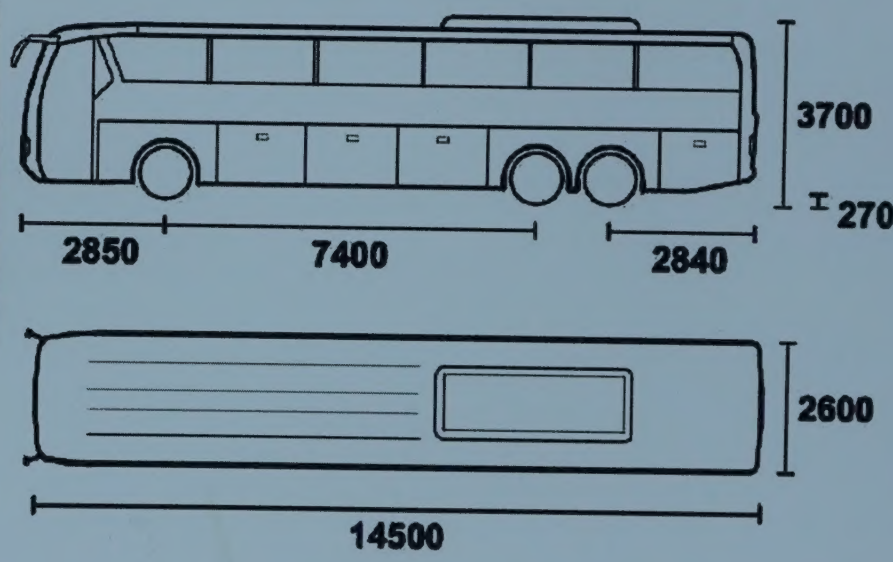
Once these buses were used in the city of Delhi, but were scrapped, due to long dwell time at the stops. In Mumbai, these buses are still used by BEST for certain routes.

(e) Sleeper Bus



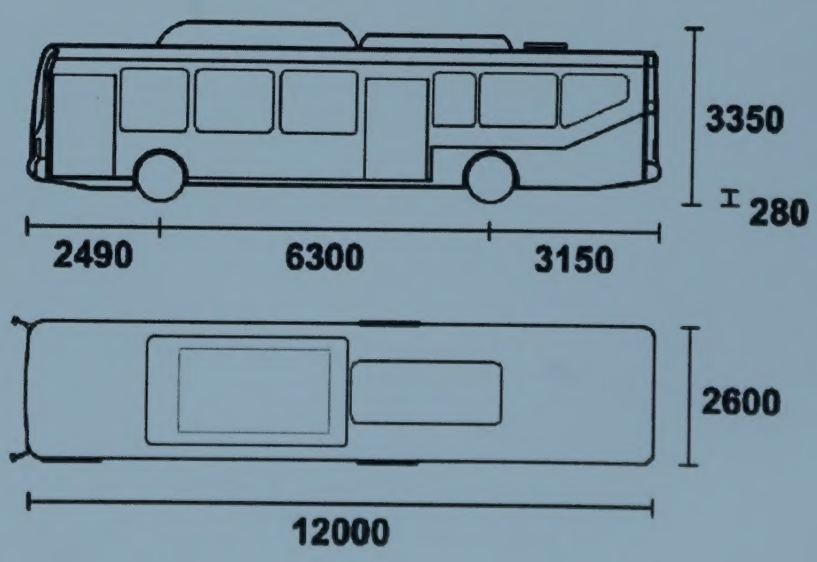
Examples:
- **MSRTC.**
- **KSRTC.**

(f) Multi-Axle Bus



Examples:
Haryana Roadways Volvo.

(g) Battery Electric Bus

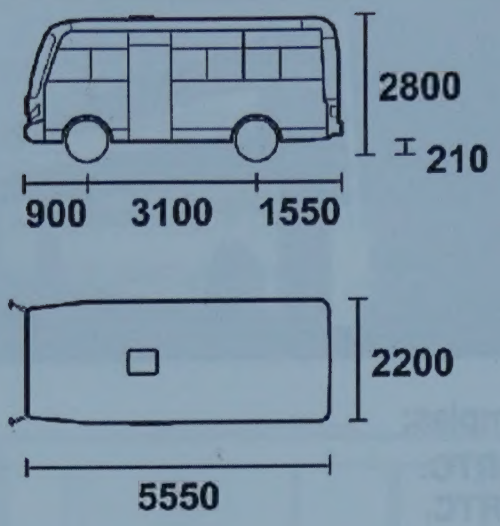


Examples:
DTC Electric Bus

***Dimensions of Electric buses are same as that of Low Floor buses.**

(h) Minibus Bus

Examples:
Intracity Bus



(The Official amendments to this document would be published by the IRC In its periodical, 'Indian Highways' which shall be considered as effective and as part of the code/guidelines/manual, etc. from the date specified therein)

Price : ₹ 600/-
(Plus Packing & Postage)